a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physical Sciences
Astronomy: The Moon

Science and Mathematics Education Research Group

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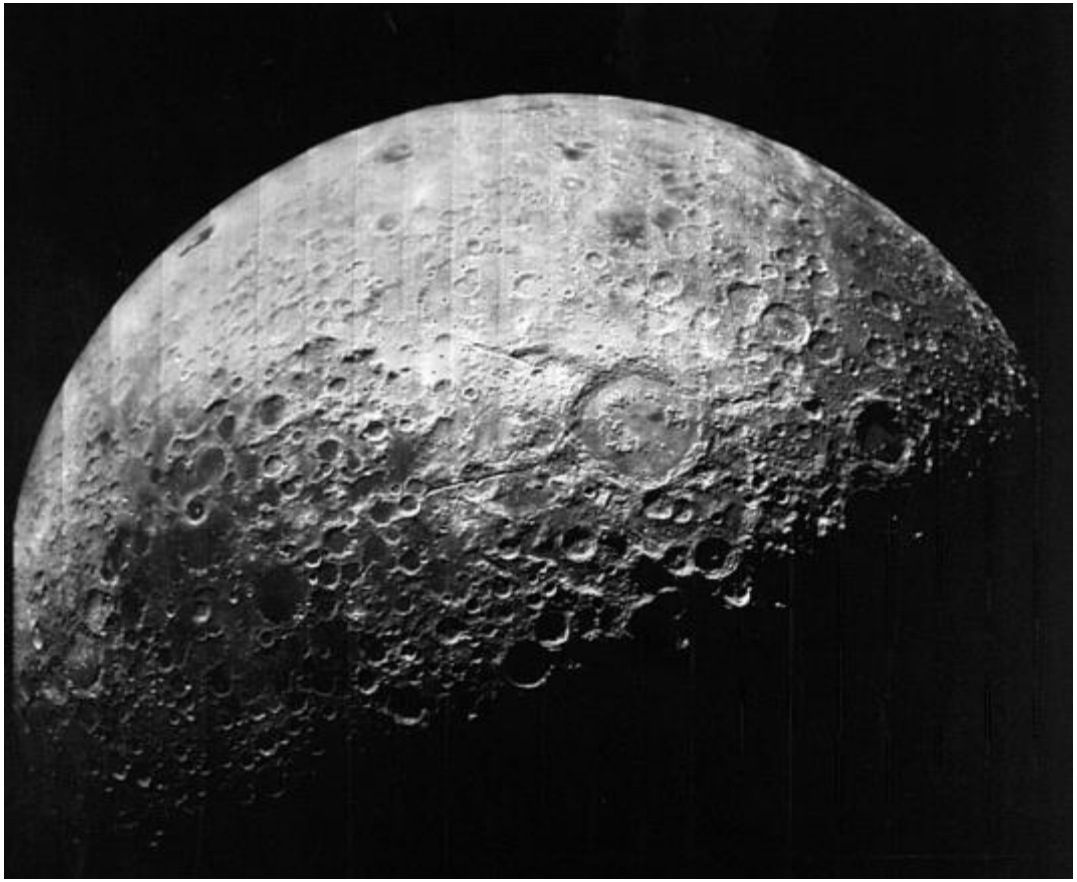
Moon Formation and Lunar Tides



GIF

This Presentation Contains GIFS

When viewed from the PowerPoint editor GIFs will not activate, and you will only be able to see the first frame of the animation. In order to fully experience the problems set, you must view the slides containing the GIFS while in slide show mode.

GIF

The Moon's Formation and the Lunar Tides

To make sure you do not miss any GIFS while presenting the question set pay attention to the top left corner of the slides. If the top corner says GIF, than you should switch to slide show (if you are not already in it) in order to watch the animation.

Moon Formation I

What is believed to be responsible for the formation of Earth's moon?

A. The Earth collided with another planet. The debris from the collision condensed to form the Moon.

B. During its formation, the Earth attracted rings similar to those around Saturn. These rings then condensed to form the Moon.

C. The Earth fragmented during its formation. A piece of the Earth then formed the Moon.

D. A stray asteroid was caught in Earth's gravitational field. This asteroid is now stuck in Earth's orbit, and we call it the Moon.

Solution

Answer: A

Justification: Although all answers are possible methods for the formation of moons, our moon is believed to have formed because of a massive collision approximately 4.5 billion years ago.

Scientists rule out the other theories for the formation of the Moon due to the relative sizes, the orbital and rotational speeds, and the elemental composition of the Earth and the Moon.

The other ways of moon formation described are believed to have happened within our solar system.

Extend Your Learning: Video ‘Why is there a moon?’

Extend Your Learning: Video ‘Why is there a moon?’

Moon Formation II

Which of the following planets could attain an additional moon in the future?

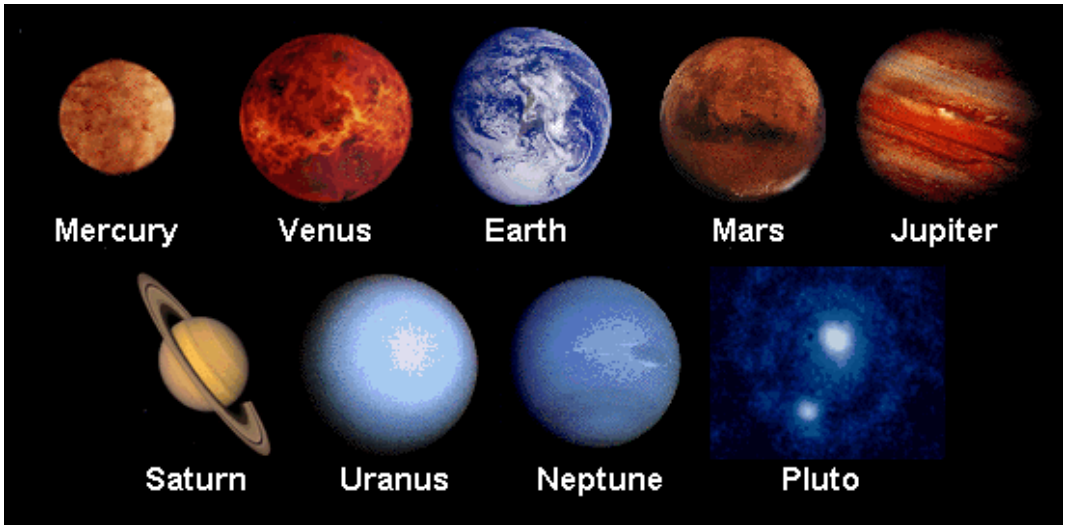
A. Earth

B. Mars

C. Jupiter

D. Neptune

E. All of the above



Solution

Answer: E

Justification: Any planet could potentially acquire an additional moon because of the “collision” and “capture” theories of moon formation. For example, a planet can potentially capture a stray asteroid, or be struck by such a large asteroid/planetoid that the debris forms a moon.

Moon Formation III

Which of the following statements might support the catastrophe theory (a Moon formed through collision) for the formation of the Earth's moon?

1. The elemental composition of the Moon's surface matches that of Earth's.
2. The Moon isn't very dense for its size, and has a very small iron core.
3. A giant crater was found on the Earth's surface.
4. There is fossil evidence of mass extinctions on Earth.
5. The Moon's surface was once a sea of magma.

A. 1, 2, 3, 4 B. 1,2,3,5 C. 2,3,5 D. 1,2,4, E. 1,2,5

Solution

Answer: E

Justification: Statement one can be considered evidence for catastrophe theory because it supports the idea that the Moon is formed from the debris of the Earth, as would be the case in the collision model.

Statement two is evidence for the collision model because it suggests the Moon formation was not like the formation of the planets or other planetesimals (formed via condensation), and the collision model is a reasonable alternative.

Statement five supports the collision theory as the fact that the Moon's surface was once almost entirely molten suggests that the Moon formed from molten rock, which would be the case in the collision theory.

Solution

Statement three cannot be considered evidence for the collision model of the Moon’s formation, because the collision was so powerful that it melted the entirety of earths crust leaving no surface for a crater to be preserved in.

Statement four is not considered evidence because the Moon is theorised to have formed before the existence of life on the planet Earth, and therefore there were no life forms to fossilize during the collision.

Moon Formation IV

What is the cause cause of the dark, smooth patches on the surface on the Moon (also called lunar mare)?

A. Oceans on the surface of the moon

B. Reflections of the Earth's oceans

C. Giant valleys in the Moon's surface

D. Patches of once melted rock

Solution

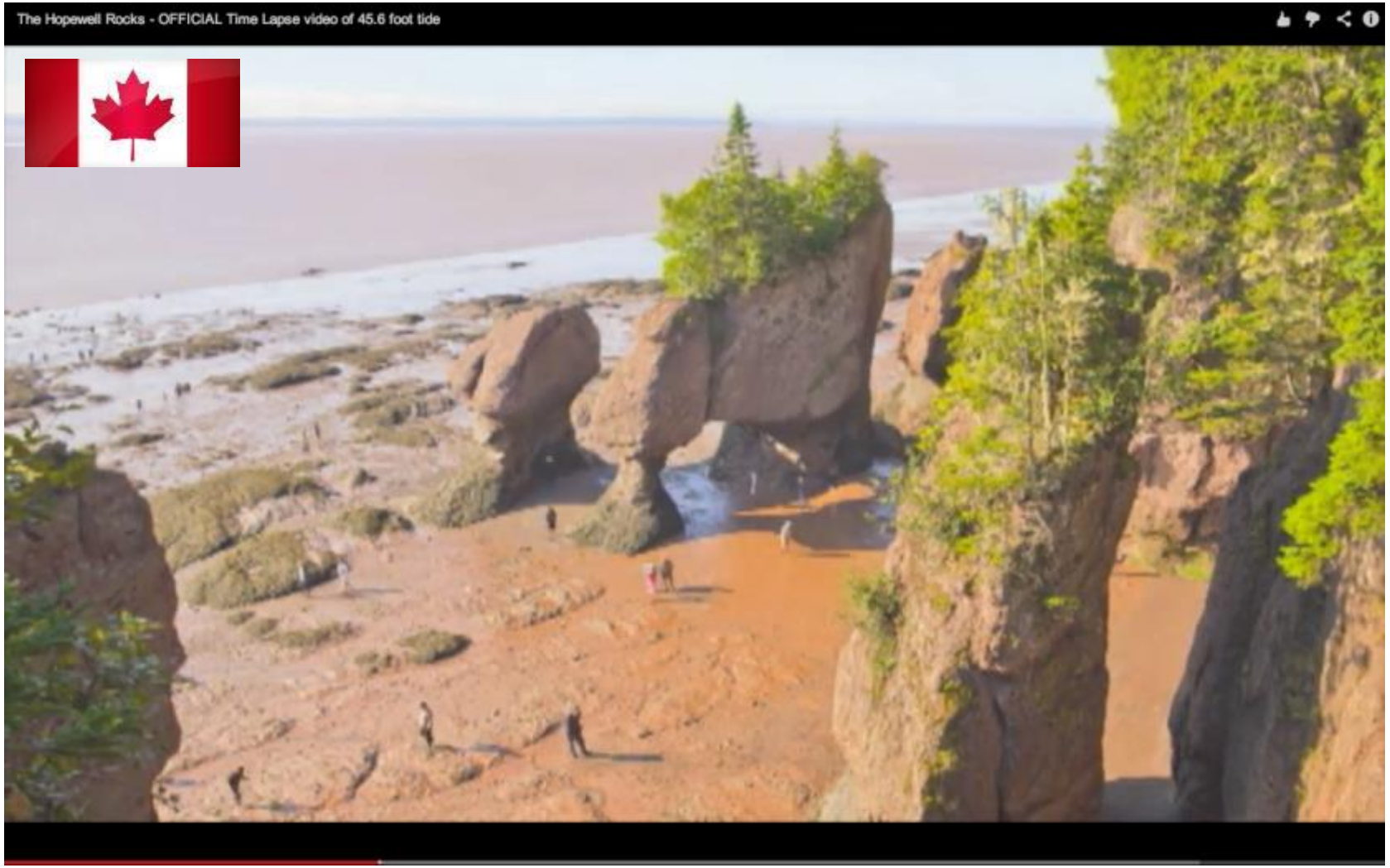
Answer: D

Justification: The dark patches on the Moon were formed by asteroids impacting on the moon and melting its surface.

Although they are not oceans, or the reflections of oceans, the dark spots do get their names from the Latin word for sea. The lunar mare got its name because when early astronomers first looked at the moon through a telescope, they thought they looked like oceans on the Moon.

Extend Your Learning: Video
‘Evolution of the Moon’s Surface’

Extend Your Learning: Video ‘Ocean’s Lunar Tides’



Lunar Tides I

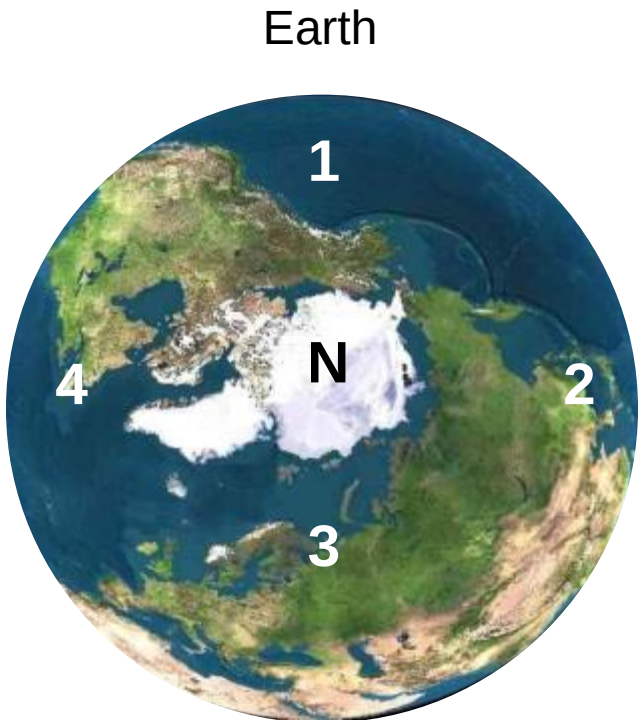
Which location(s) are experiencing high tide?

A. 2

B. 3 & 1

C. 4 & 2

D. 4

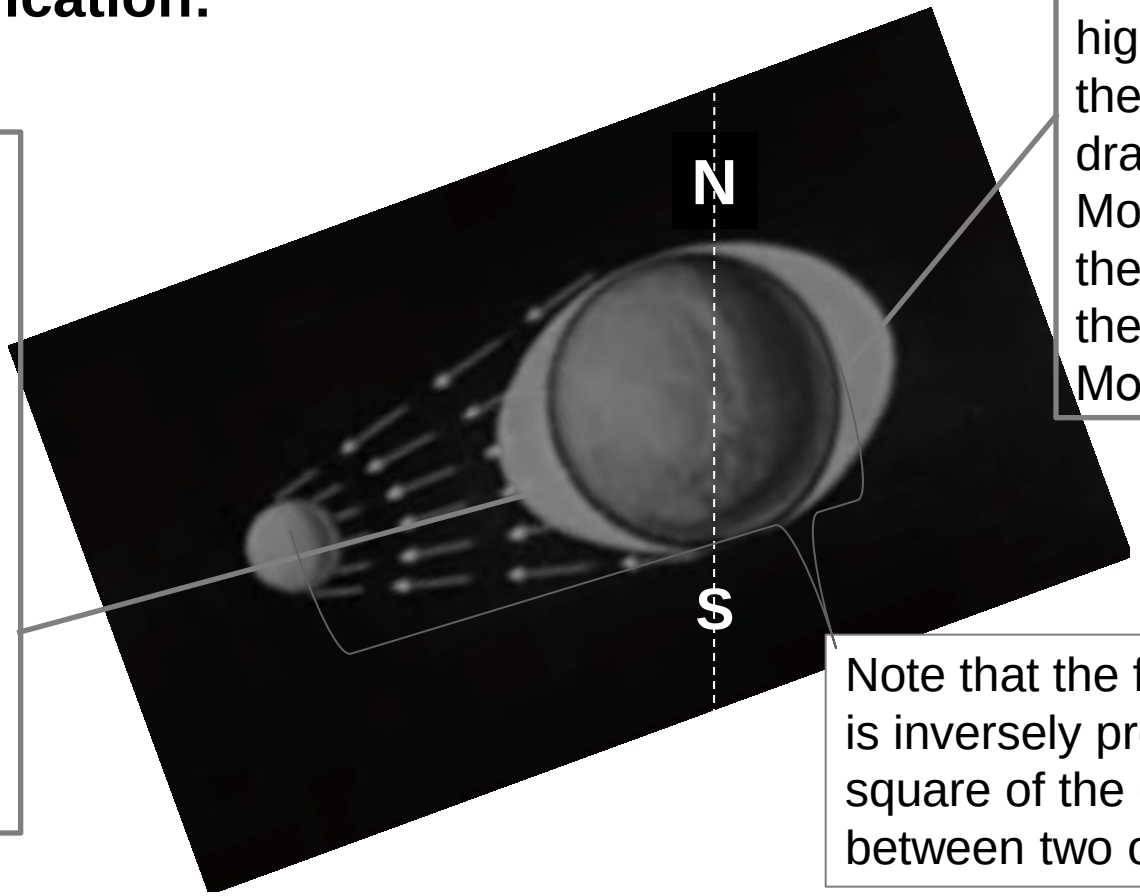


Solution

Answer: C

Justification:

The side of the Earth closest to the Moon experiences high-tide because the ocean is drawn away from the surface of the Earth under the effect of the Moon's gravity.



The opposite side of the Earth will also experience high-tide because the Earth itself is drawn towards the Moon, away from the ocean under the effect of the Moon's gravity.

Note that the force of gravity is inversely proportional to the square of the distance between two objects.

Lunar Tides II

Which of the following explanations properly justifies why locations 1 and 3 are experiencing low-tide?

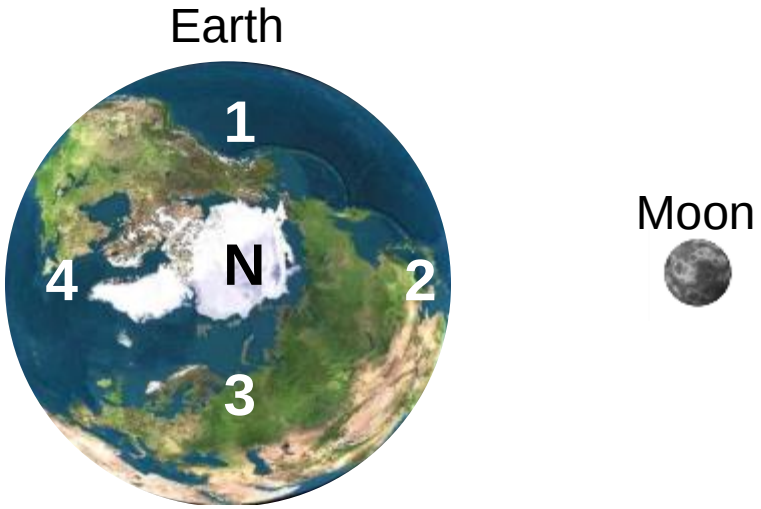
Due to the Moon's gravity:

A. The Earth's crust bulges at 1 and 3, causing the water at 1 and 3 to appear more shallow.

B. The Earth's crust bulges at 2 and 4, causing the water at 1 and 3 to appear more shallow.

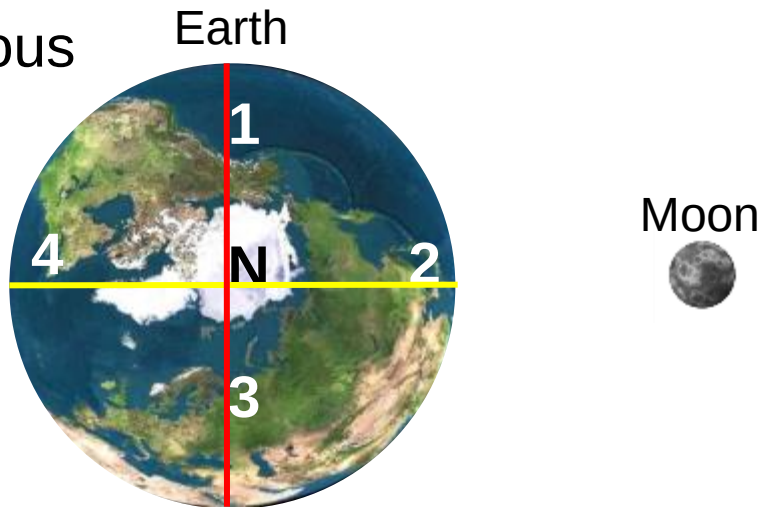
C. Water flows to locations 2 and 4, causing a decrease in ocean depth at 1 and 3.

D. Water flows to locations 1 and 3, causing a decrease in ocean depth at 1 and 3.



Solution

Answer: C



Justification: As discussed in the previous question, high tides are the result of the ocean being pulled more than or less than the Earth's center of mass. However, the surface of the Earth that is in-line with the Earth's center (portrayed by the red line through locations 1 and 3) is not being significantly effected by either the positive pull of the Moon's gravity, or the lack of pressure from the Earth's crust. The water flows from areas 1 and 3, to areas 2 and 4, in a similar way to how water will flow down a hill.

Lunar Tides III

How often will a particular beach experience high-tide?

A. Twice a month

B. Once a month

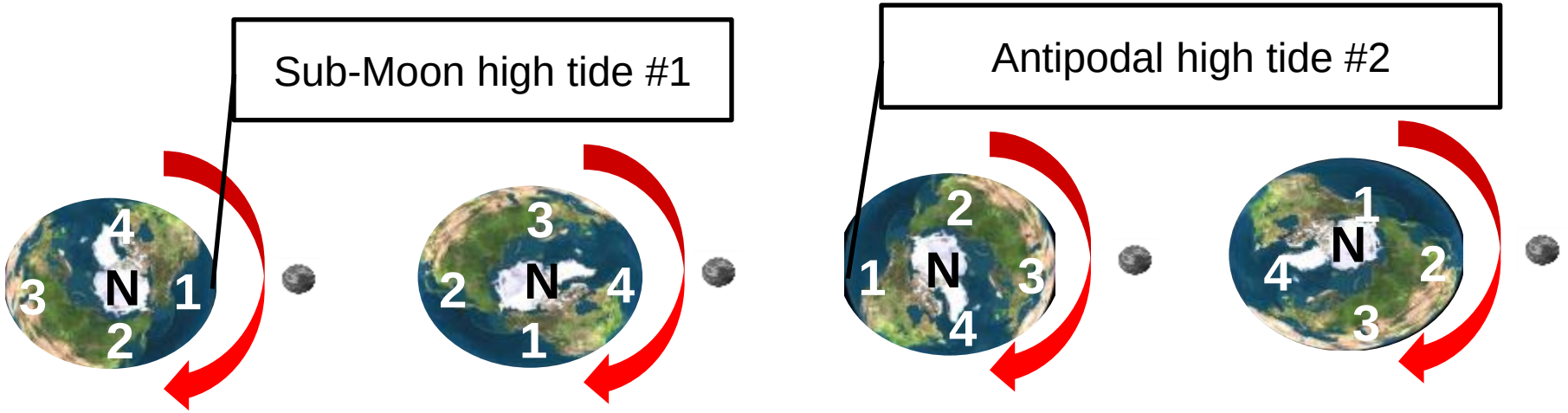
C. Twice a day

D. Once a day

Solution

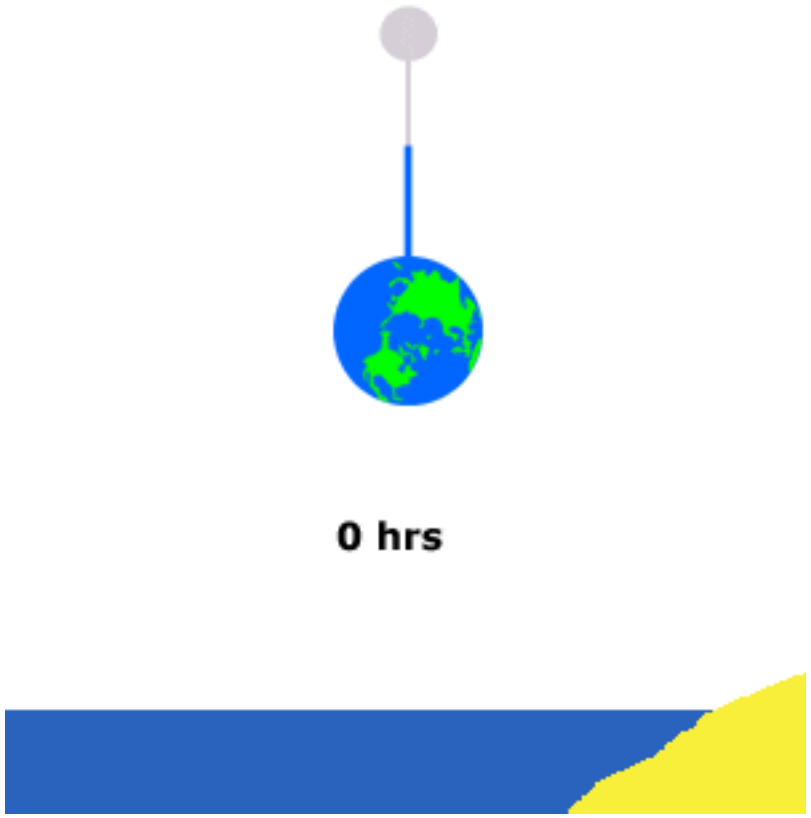
Answer: C

Justification: Each beach on the surface of the Earth experiences two high-tides per day because the Earth rotates about its axis once every 24 hrs. Because the Moon's orbital period is much larger than the Earth's rotational period, we can think of the Moon as being stationary while the Earth orbits beneath it.



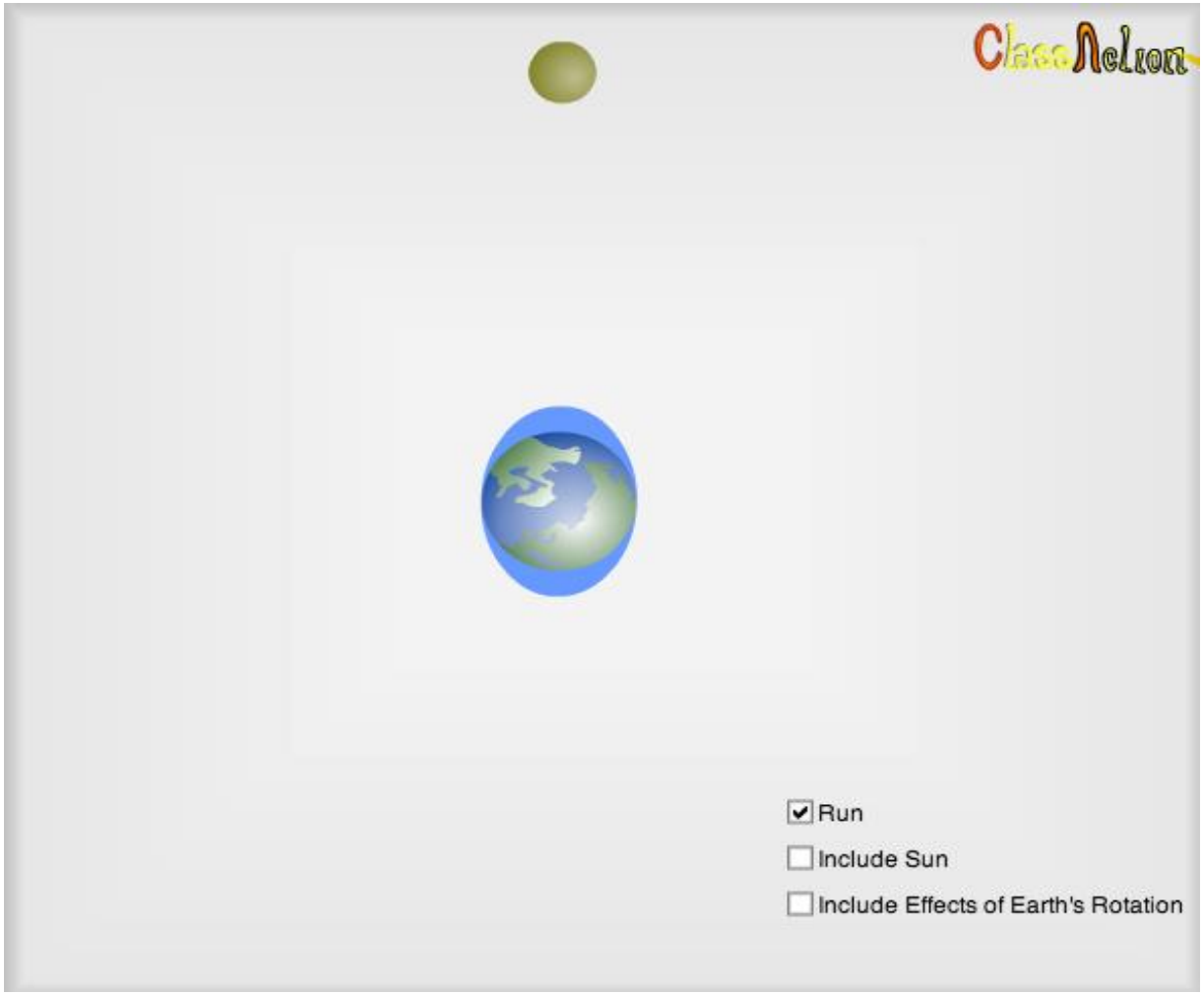
During a full rotation each point on the Earth passes through the Antipodal and Sub Moon areas in space, experiencing two high tides.

Extend Your Learning: GIF



Extend Your Learning: Video ‘Tidal Resource’

Extend Your Learning: Animation



Moon Formation V

What could explain the fact that the Earth is less cratered than the Moon?

1. The Earth is made of harder material than the Moon
2. The Moon is closer to the asteroids than the Earth
3. The Earth's craters erode
4. The Moon has no atmosphere for protection

A. 1, 2
B. 1, 2, 3
C. 2,3
D. 3,4
E. All of the above.

Solution

Answer: D

Justification: The Earth's atmosphere protects the Earth from asteroids because, when asteroids enter the atmosphere, air friction causes the asteroids to combust and lose mass. Any craters that do form on the Earth's surface are eroded over time by Earth's weather.

In fact, more asteroids have entered the Earth's atmosphere than have hit the Moon, but the Moon doesn't have an atmosphere to protect it or weather to erode the craters, and therefore appears to be more cratered than the Earth.

Solution

We should know that statement 1 cannot be correct because we are familiar with the theory of our Moon's formation, and the fact that the Moon is created from the same material as the surface of the Earth.

Statement 2 does not explain why the Moon is more cratered than the Earth, because of the symmetric nature of the Moon's orbit. It is equally likely that the Moon will be shielding the Earth or the Earth will be shielding the Moon.

Additionally, because the Moon is so much smaller than the Earth, the effects of the the Earth shielding the Moon is much greater than the Moon shielding the Earth. This results in the protection of the Moon by the Earth.

Extend Your Learning: Video ‘Meteor In Atmosphere’

Observing the Moon VI

There are three friends, one in Vancouver, Canada, one in New York City, USA and another in Tokyo, Japan. Each friend takes a picture of the full moon in their own city.

To their surprise the markings on the Moon look the same in each of their photos. What is the best explanation for the similarities ?

A. Unlike the Earth, the Moon does not spin about its axis

B. The Moon has a “dark side” and a “light side”, but we only ever see the “light side” of the Moon

C. The Moon’s orbital period is the same as its rotational period

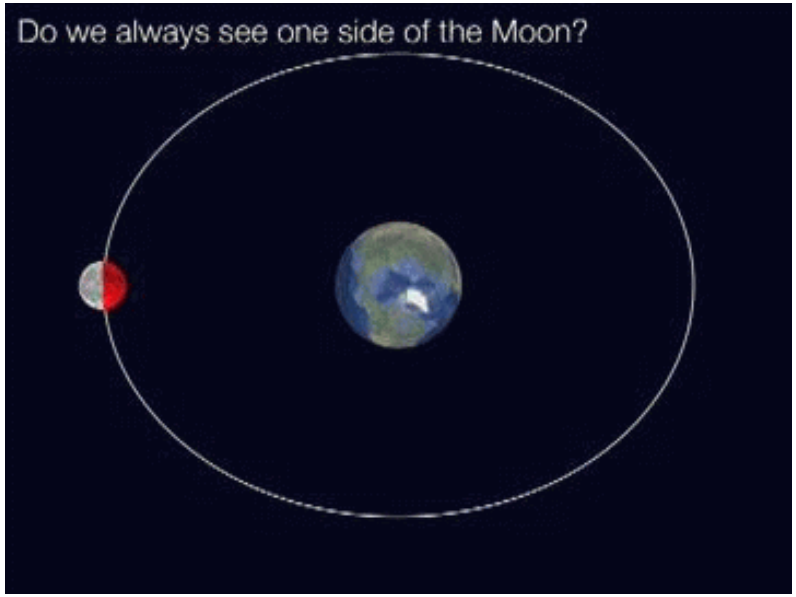
D. The Earth’s rotational period is equal to the Moon’s rotational period.

GIF

Solution

Answer: C

Justification: The Moon orbits the Earth at the same rate it rotates about its own axis, this is why we only ever see one side of the Moon from Earth. This means that as the Moon orbits the Earth, it spins about its axis at the speed required to maintain the same side facing the Earth at all times.



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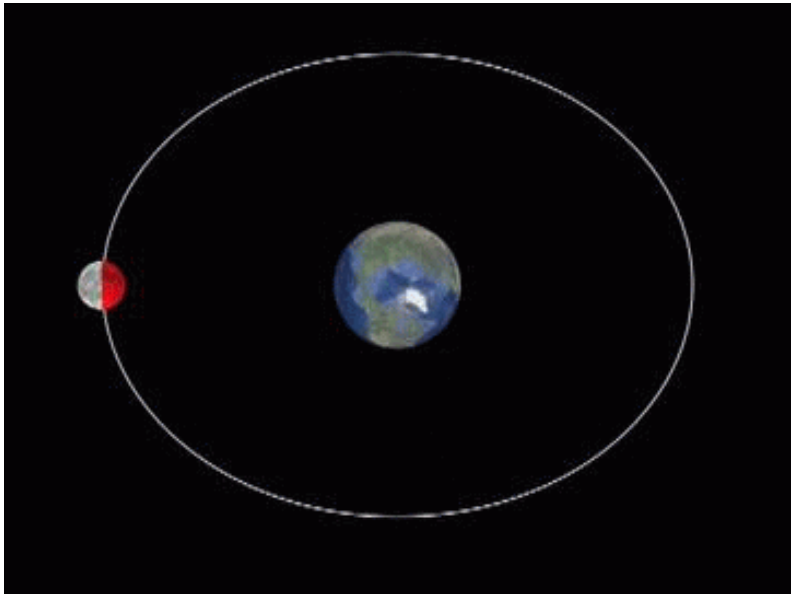
Solution

Now lets look at why answers A, B and D fail to describe why the same side of the Moon is always visible from Earth.

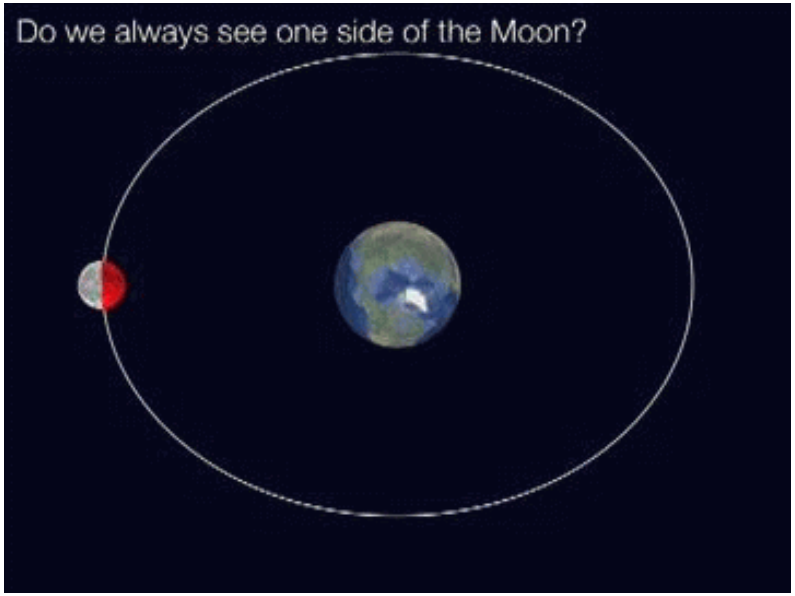
If the Moon did not spin about its axis then both sides of the Moon would be visible from Earth through the full orbit of the Moon. Here is a GIF that demonstrates the Moon's orbit if the Moon did not spin about its axis. You can see that the Red side of the Moon does not face the Earth for the entire orbit.



GIF

Solution

Remember that in order for one face of the Moon to remain observable from Earth at all times there must be a specific relationship between how quickly the Moon orbits the Earth, and how quickly the Moon rotates about its own axis.



The Earth's rotational period only governs how quickly the Earth rotates beneath the Moon. It does not contribute to the relationship described above. Therefore answer D by itself does not explain the similarities found in the friends'

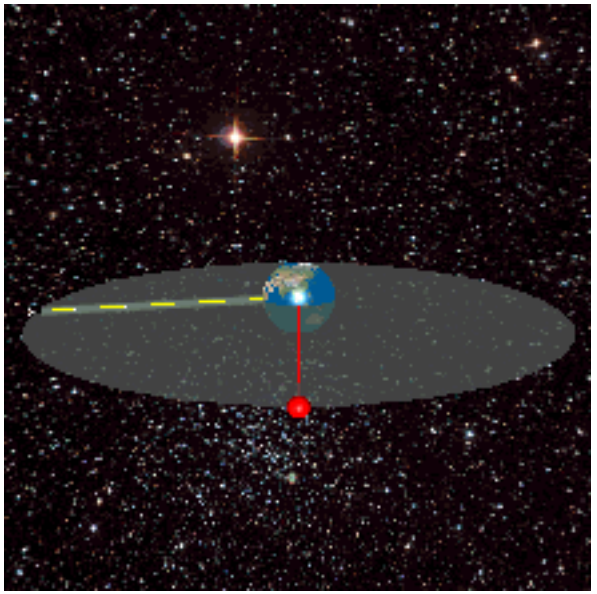
GIF

Solution

If the Earth's rotational period, the Moon's rotational period, and the Moon's orbital period were all equal, we would have what is called a "geosynchronous orbit".

Objects in a geosynchronous orbit maintain their position and facing relative to Earth's. This fact makes geosynchronous orbits important for communication and surveillance satellites.

Satellites in geosynchronous orbit



Extend Your Learning: Video ‘The Moon’s Orbit’