a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Earth & Space Science
Exploration of Extreme Environments: Satellites

Science and Mathematics Education Research Group

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Satellites

Satellites I

Satellites can be natural or man-made (also known as artificial).

What do both of these types of satellites have in common?

A. They both remain in space forever

B. They both orbit around a larger object in space

C. They both started as a payload and were launched into space

D. They both communicate with other satellites

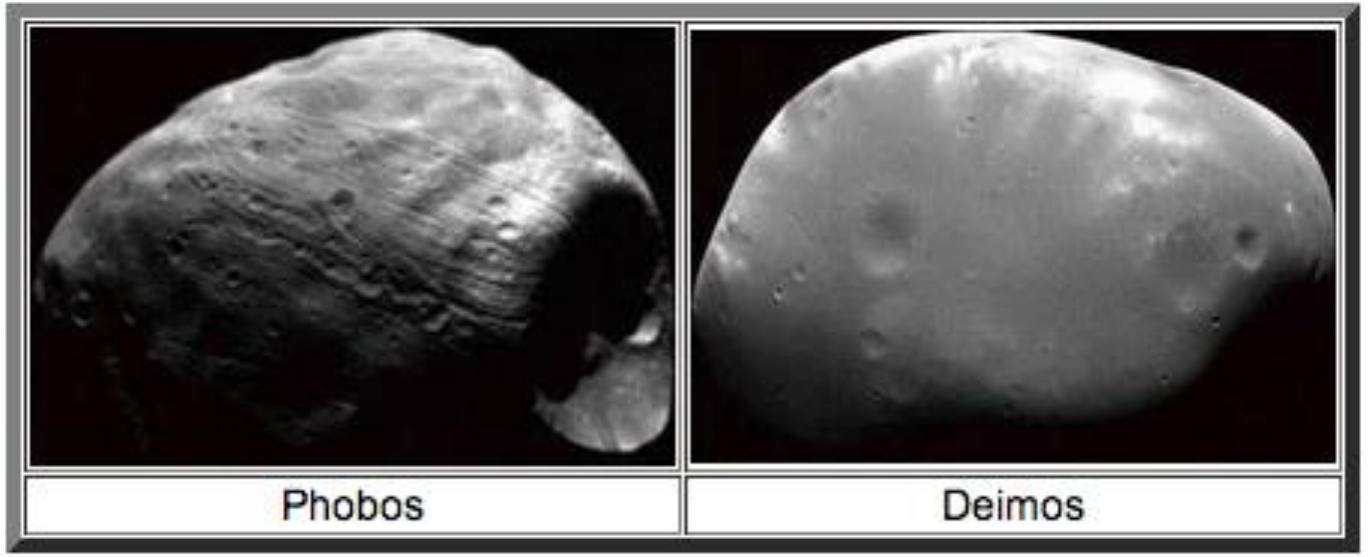
E. They both orbit the earth

Solution

Answer: B

Justification: By definition, satellites are objects that orbit another (larger) object in space. It is commonly thought that objects must orbit a planet to be a satellite; however, satellites may also orbit stars. Satellites orbit other planets too, not just Earth.

Mars has two moons (right), which are natural satellites.



Solution Cont'd

Man-made satellites, also known as artificial satellites, are intentionally placed into orbit. They can be launched into space or brought back down to Earth to fill specific purposes.

Currently, NASA has more than a dozen man-made Earth science satellites in orbit.

Satellites II

Which of the following objects is NOT a satellite?

A. The moon

B. The International Space Station

C. Jupiter’s largest moon, Ganymede

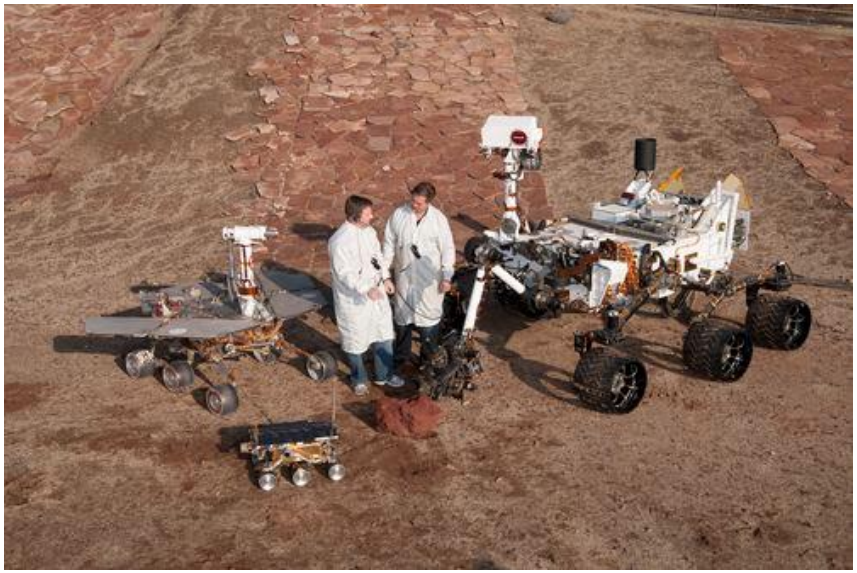
D. The Hubble Space Telescope

E. Mars Rover, Curiosity

Solution

Answer: E

Justification: *Curiosity* is a rover that successfully landed on the surface of Mars on August 6, 2012. It was launched from Earth and traveled through space directly to Mars as a payload in a larger spacecraft.



Our moon and Jupiter's moon Europa are both natural satellites that orbit planets. The International Space Station and the Hubble Space Telescope are both man-made satellites that were intentionally placed into orbit around Earth.

Satellites III

A **payload** refers to anything that is launched into space.

Which of the following would be the best example of a payload?

A. The moon

B. A booster rocket

C. A communication satellite

D. Radio waves

E. Global Positioning System (GPS)

Solution

Answer: C

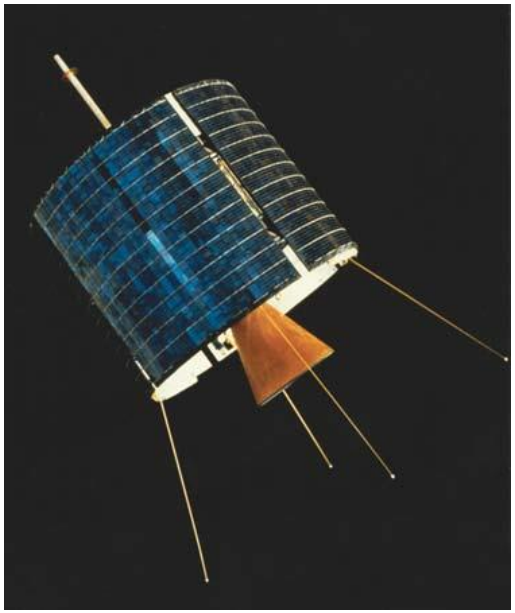
Justification: The moon is Earth's natural satellite, and it was born and will remain in space as all natural satellites do.

Booster rockets assist a spacecraft to gain the thrust needed to escape the earth's atmosphere. Once they have used up all of their fuel, they detach and fall back to the earth's surface.

Radio waves are a type of electromagnetic radiation. They are invisible waves that travel through the Earth's atmosphere as well as the vacuum of space.

GPS use many satellites to operate. While these satellites would have been payloads launched into space at one point, the GPS remain on Earth, and have not been launched into space.

Solution cont’d



Many communication satellites orbit Earth in order to provide various communication links across the globe. For example, these satellites increase the speed of television and telephone communication. These satellites are made on Earth and then launched into space as a payload.

These satellites must be able to withstand the shock of a launch into orbit at a speed greater than 28 000 km/h. Satellites must be small and made of lightweight materials in order to remain intact in an environment of high radiation and extreme temperature. Many satellites have an operational lifetime of up to 20 years.

Satellites IV

What do man-made satellites do to help us better understand our world?

A. Take pictures of places that are not easily accessible to humans

B. Track migration patterns of endangered species

C. Predict the weather and climate by observing clouds

D. Enable communication across far distances around the world

E. All of the above

Solution

Answer: E

Justification: Satellites are powerful technologies that have advanced our understanding of the world we live in. There are thousands of man-made satellites in orbit around the earth. These satellites have the capabilities to take pictures of the earth from space. This provides people with information that we are not able to obtain from the planet's surface.

With this information, we are able to study and predict weather and climate patterns and track the migration patterns of endangered animals to help protect them.

Solution cont’d

Satellites are also able communicate with each other; usually via radio wave transmitters. Because of this, we are able to communicate anywhere on Earth quickly.

The International Space Station (ISS) is a famous satellite in orbit around Earth. The first piece of the space station was launched in 1998. The ISS is made up of many smaller pieces which were launched individually and connected in space. Astronauts conduct a variety of studies on the ISS that would be impossible on Earth.

Satellites VI

How does the force of gravity affect a satellite's orbit?

A. An object in orbit does not experience gravitational force

B. Gravity keeps a satellite in orbit around a planet

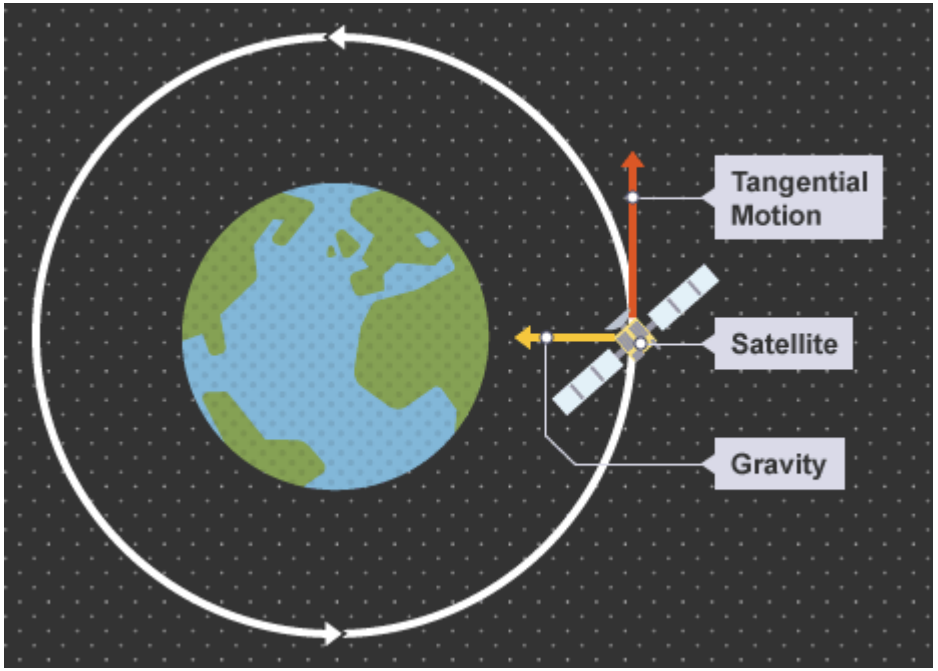
C. In the absence of gravity, satellites would continue to orbit Earth

D. Satellites orbiting planets escape gravitational pull

Solution

Answer: B

Justification: All objects are attracted to larger objects due to the force of gravity. This is especially visible when we talk about planets, moons, and other objects in space. In order to "escape" the pull of Earth's gravity, it would be necessary to travel very far.



If the earth did not exert a gravitational force on the objects that orbit it, they would float away in to space. The earth's gravity is what holds satellites in orbit around it.

Extend Your Learning: Video

Title: Free falling in outer space

Satellites VIII

“Geo” refers to Earth and “synchronous” refers to things occurring at the same time.

Which situation best describes an object in geosynchronous orbit?

A. A natural satellite that remains in the same location over Earth

B. A natural satellite that orbits Earth in the opposite direction of Earth’s rotation

C. A man-made satellite that remains in the same location over Earth

D. A man-made satellite that orbits Earth in the opposite direction of Earth’s rotation

Solution

Answer: C

Justification: A geosynchronous orbit is sometimes called a geostationary orbit. Satellites in geosynchronous orbits make one full trip around the Earth in the same amount of time it takes the Earth to make one full rotation. These satellites are always above the same location on Earth's surface.

By positioning a satellite in one place at the same time, we are able to monitor Earth's weather and provide satellite television to homes – that's why satellite dishes are always pointed the same way in the sky.

Geosynchronous satellites are intentionally launched to enter a geosynchronous orbit, and so can only be man-made.

Extend Your Learning: Types of Satellites

There are many types of satellites and orbital shapes, each used for a different purpose. Geosynchronous and polar orbits are the most common.

Orbit	Description	Example
Low Earth Orbit (LEO)	High enough that it misses mountain peaks but doesn't gravitate back toward Earth	ISS, Hubble Space Telescope
Medium Earth Orbit (MEO)	Orbits between Low Earth orbits and Geosynchronous orbits	GPS' 24 satellites
Geosynchronous Orbit (GSO)	Always above one spot on Earth; great distance from Earth	Communication satellites
Polar Orbit	Travel north-south from pole to pole	Weather satellites
Elliptical – shape of some orbits	Orbital path is an ellipse (oval-shaped). Speed of the satellite increases when it is closer to the object it orbits.	GPS' 24 satellites

Satellites IX

How long does it take for a satellite in geosynchronous orbit to complete one full orbit?

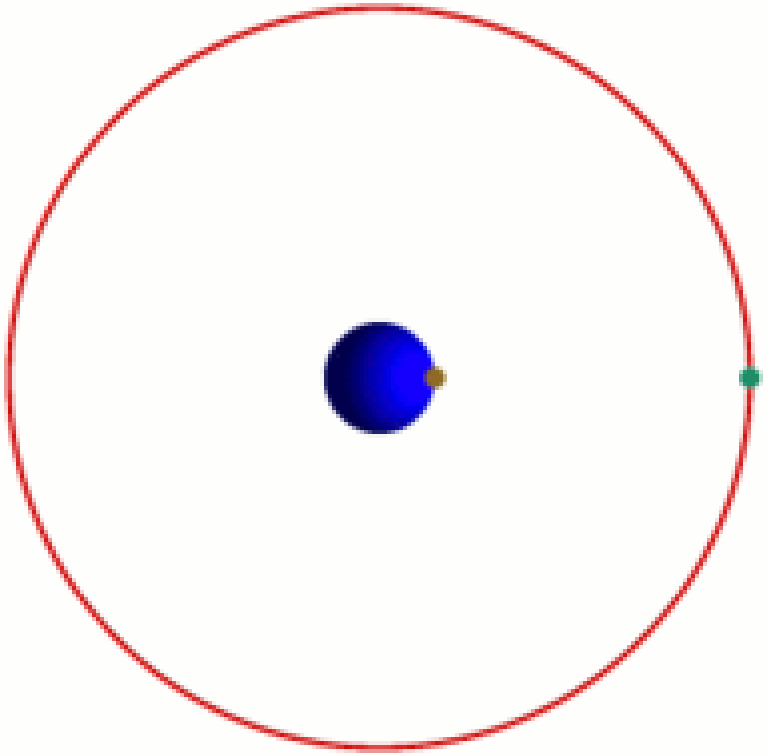
A. 1 year

B. 1 month

C. 24 hours

D. 12 hours

E. 1 hour



Solution

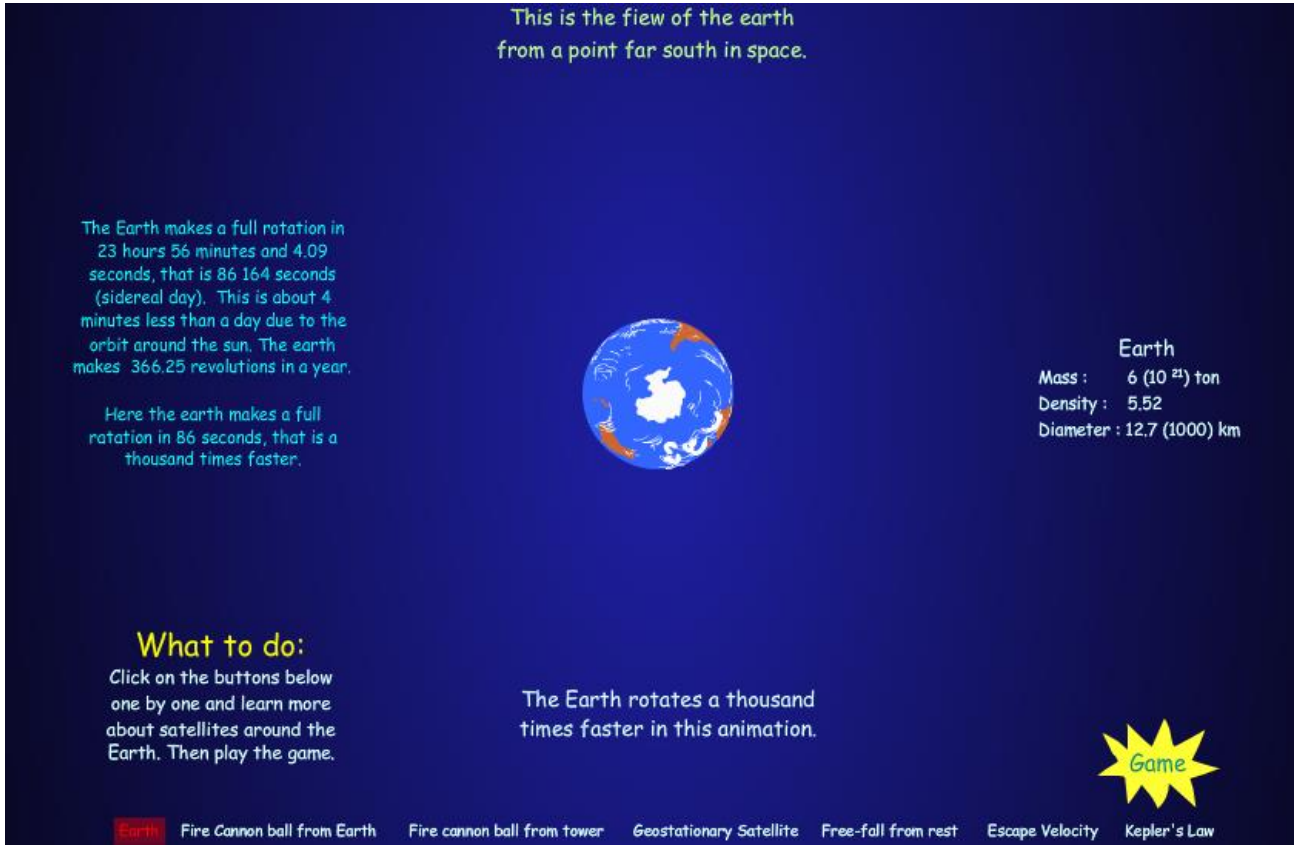
Answer: C

Justification: Since a satellite in geosynchronous orbit is always above a specific spot on Earth, it will travel in one full circle in the same amount of time that the Earth rotates once on its axis, 24 hours.

Because a satellite in geosynchronous orbit is very far from the centre of the earth, it will have to travel a much farther distance during a single orbit than the a point on the Earth would cover during one rotation. So, the speed at which the satellite travels is much faster than the rotation of the earth.

Extend Your Learning: Simulation

A simulation of a geosynchronous orbit.



Extend Your Learning: Experiment

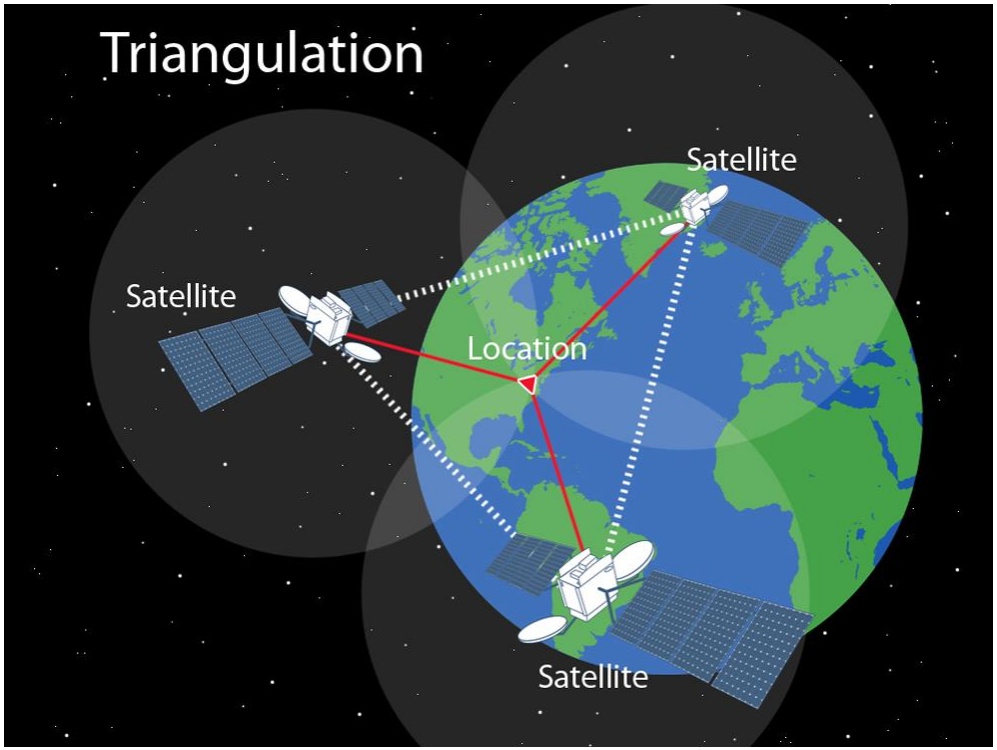
You can experience this phenomenon as well. In fact, if you've ever skated in a circle while holding hands with others, you may already have!

Needed	• 5-10 people • Large indoor or outdoor space (gym or field)
Procedure	• Stand shoulder-to-shoulder in a line, with everyone facing the same way • Link arms • The persona on the end remains stationary • Keeping the line as straight as possible, start walking around in a circle

What do you observe? How does a person's position in the line affect how fast they are traveling? Who is traveling fastest?

Extend Your Learning: Did You Know?

In order to pinpoint a specific location on Earth, a GPS device uses a process called **triangulation**. Three satellites measure the distance to each other in a triangle using radio signals. They also connect with the GPS device on Earth. This space makes an upside down pyramid with the tip being the location on Earth where the GPS device it located.



Think about it: When was the last time that you "used" a satellite?

Satellites XI

A GPS works by communicating with satellites in orbit to triangulate the location of the system on the surface of the planet. The satellites travel in elliptical, or oval-shaped, orbits around the earth.

Why do these satellites travel in elliptical orbits?

A. A GPS must be able to locate four satellites in orbit around earth in order to confirm its location on the surface.

B. Satellites often malfunction, so if one satellite is not operating properly, there are three alternate satellites available

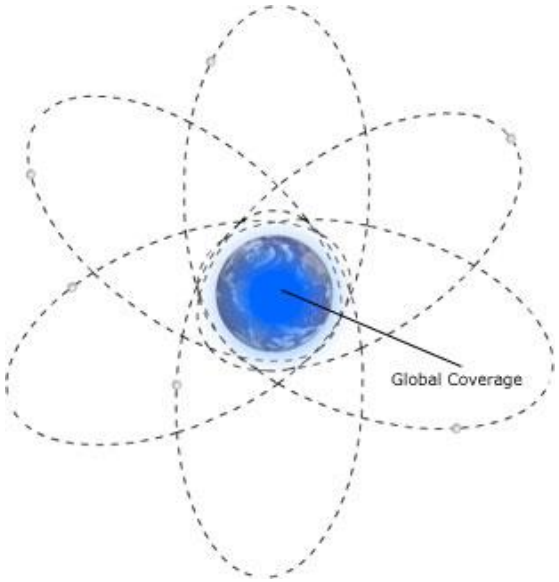
C. To minimize the distance between the satellite and the earth's surface at all times.

Solution

Answer: A

Justification: As you previously learned, GPS satellites occupy Medium Earth Orbits (MEO) in space. This means that they are orbiting above space crafts and space stations, but below communications satellites in geosynchronous orbits.

In order for a GPS to confirm a location, the system must be able to locate four of 24 possible satellites in orbit. These satellites orbit the earth in elliptical paths, as seen in this image. With 24 satellites orbiting in this pattern, a GPS receiver at ANY location on Earth can locate at least four satellites.



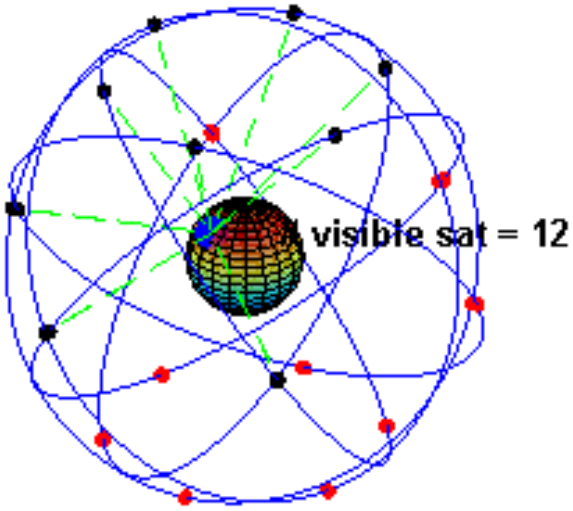
Solution Cont'd

When a GPS receiver requires direction, it locates any 4 of the 24 active satellites in MEO. These satellites communicate with each other as well as the receiver to pinpoint an exact location on Earth. All of these satellites are necessary for GPS to be successful in finding a location on Earth.

Have you ever used a handheld GPS receiver like the ones pictured to the right? Sometimes GPS devices do not work momentarily, especially in urban areas with large skyscrapers. This is because the tall buildings are blocking the receiver's path to one or more of the GPS satellites in orbit.

GIF

Extend Your Learning: Animation



A visual example of a 24 satellite GPS constellation in motion with the Earth rotating. Notice how the number of **satellites in view** from a given point on the Earth's surface, in this example at 45°N, changes with time.

Extend Your Learning: Video

Title: Satellite GPS