8.3 Satellites

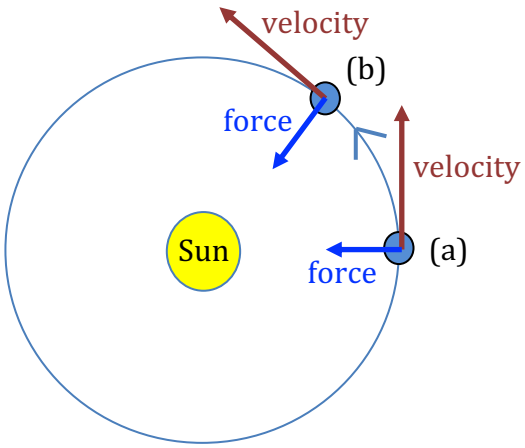
Satellites are smaller objects which orbit a larger body. For example, the Moon is a natural satellite of the Earth, and the Earth is a natural satellite of the Sun. There are also artificial satellites which orbit the Earth. Artificial satellites are designed for different functions, such as relaying radio signals, SAT-NAV, surveillance, weather monitoring, space obseravtion, etc.

(1) Name a natural satellite of the Sun, other than the Earth.

(2) Name a natural satellite of Mars. (Hint: You will need to look this up.)

There is a gravitational force of attraction between any two bodies with mass. This is the only force that keeps objects in orbit.

Consider the orbit of the Earth around the Sun:



The orbit of the Earth is approximately a circle (It is slightly elliptical). It orbits at a constant speed. However, its velocity changes. You can see that by comparing the velocity vectors at positions (a) and (b) in the orbit. The length of the velocity vector remains constant (i.e. the speed remains the same), but the direction changes. The gravitational force acting towards the Sun causes the velocity to change.

(3) What direction would the Earth move in if there was no gravitational force acting on it at position (a)?

(4) Why does the unbalanced force acting on the Earth not cause it to speed up or slow down?

As two objects are brought closer together, the gravitational attraction increases. To maintain a stable orbit, the orbiting object needs to move with a greater speed. This is why planets closer to the Sun have shorter orbital periods. They have a shorter distance to travel, but they are also moving more quickly.

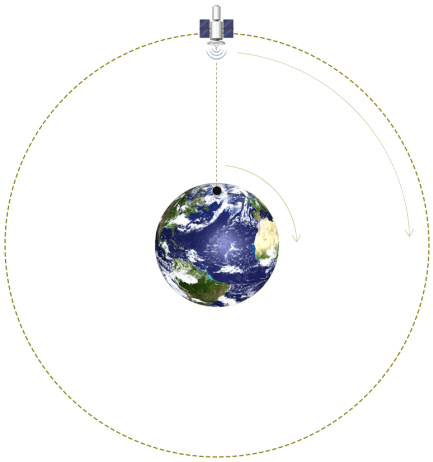
(5)✎ Which planets in the Solar System would you expect to have the i) shortest, ii) longest orbital periods?

(6)✎ The Earth->Moon distance has increased since formation. How would expect the orbital period of the Moon to have changed over time?

Artificial satellites

Geostationary orbit

Geostationary satellites orbit the Earth's equater once every 24 hours in the same direction that the Earth is rotating. This means that they remain over the same position on the Earth's surface. This useful, for example, for satellites that transmit satellite television. If the satellite moved then the satellite receiver dish would have to also have to move.



(7)✎ The radius of a geostationary satellite is $4.2 \times 10^7 m$*. What speed do they orbit at? (Hint: Work out the circumference of the orbit and divide by the time taken in seconds.)*

Polar orbit

Some satellites orbit over the poles. As the Earth rotates the satellite will pass over a different strip of the Earth's surface. This is useful for satellites that need to scan the whole of the Earth's surface (e.g. for mapping or for monitoring global weather.).

(8)✎ Satellites used for mapping or surveillance use much lower orbits than the one for geostationary satellites. Why might this be?