

UNL2207 - The Nature of Natural Law: Tutorial 5

More Gravity, Satellites & Kepler's Laws

- 1) Compare and contrast the models of the solar system due to Ptolemy, Copernicus and Kepler; list the most significant features of each. Which model do you think is the '*simplest*' and why?

- 2) Venus and the Earth are about the same size. However, viewed from Venus, at its brightest, the Earth would appear about six times brighter than Venus ever appears to an observer on Earth. Note this this occurs despite the fact that the Earth is farther away from the Sun (and the light reflectivity of Venus is greater than that of Earth). How can you explain this apparent paradox?

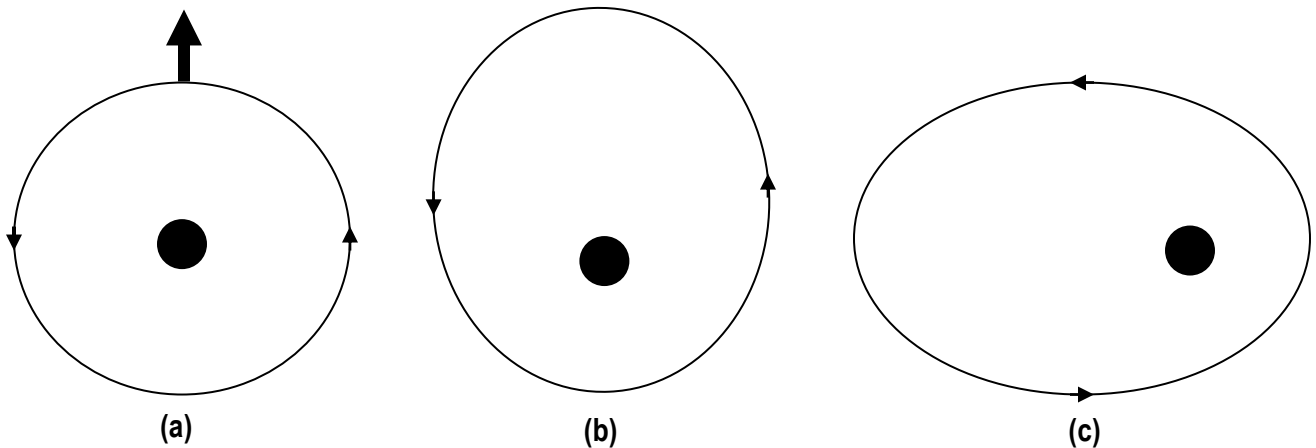
- 3) Why were the first US satellites launched from Cape Canaveral in Florida?

More generally, why do space launch sites, such as the Kennedy Space Centre at Cape Canaveral, tend to be located in the tropics?

- 4) If a rocket is launched vertically upward with a speed of 11.2 km/s and then the engine is switched off, it will be able to 'escape' from the earth's gravitational pull. Now suppose that the rocket is launched almost horizontally with the same initial speed. Neglecting air effects, will the rocket still be able to escape the earth?

- 5) You wish to launch a spacecraft so that it will reach as far out as possible into the Solar System. Which gives you the maximum range for less fuel – to launch the spacecraft in the direction of the earth's orbital speed when the earth is closest to the Sun, or furthest from the Sun?

- 6) The engines of a spacecraft in a circular orbit about the earth are fired briefly to give the craft an outward radial thrust as shown in (a) below. Will this thrust produce orbit (b) or (c)?



7) What is the effect of air resistance or 'drag' on a satellite travelling through the upper layers of the earth's atmosphere?

a) To slow the satellite down

b) To speed it up

8) Even though the Moon is much smaller than the earth (about one-quarter the radius of the earth), it takes 108 minutes to circle the Moon in the lowest orbit compared to 84 minutes for the lowest earth orbit (just skimming the earth's surface). Why is this? [Mad About Physics, page 154]

9) On average, the earth's orbit around the Sun has a radius of about 150 million kilometers and it moves around the Sun at about a speed of 30km/s. More precisely, at different points in its orbit it moves faster than this and at other points slower. When is the earth moving fastest around the Sun and when the slowest and calculate what these two speeds actually are? *Hint: the earth's perihelion is 1.471×10^8 km while its aphelion is 1.521×10^8 km.*

What speed would the earth need to have in order to just be able to escape the gravitational 'pull' of the Sun?

10) Kepler's second law or 'rule' states that the imaginary line between any planet and the Sun sweeps out equal areas in equal times as it orbits the Sun. If the gravitational attraction due to the Sun were somehow suddenly switched off and the planets therefore no longer traced elliptical orbits, would Kepler's equal area law still hold true?

11) A ball held by a string is rotating uniformly in a large horizontal circle. The string is then pulled in so that the ball now moves in a smaller circle. As it goes around the smaller circle, is the ball's speed

a) greater

b) less

c) the same

as it was for the large circle?

12) What If the earth were suddenly stopped in its orbital movement, how long would it take to fall into the Sun? *Hint: imagine a highly elongated elliptical orbit with eccentricity almost 1.*

Given the Earth's actual orbital speed, is there any danger of the Earth ever falling into the Sun?

13) As you move away from the Sun its gravity gets weaker. But suppose it did not; suppose it got stronger. If such a fictitious law were true, would it be possible for bodies such as the planets to orbit the Sun, and if so what characteristics would such orbits display? *Hint: assume a gravity force law that is proportional to r^n (with $n > 0$), and that a planet could still execute uniform circular motion.*

a) Yes, just as they presently do

b) Yes, but unlike as they presently do

c) No, orbital motion could not occur