Astronomy 1 fall 2009
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Solutions to Assignment 3

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1 Ch. 4 #9

No. Mercury is an inferior planet, and at midnight we're seeing only half of the celestial sphere directly opposite the Sun. Thus we cannot see Mercury. See figure 4-6.

Ch. 4 #12

Parallax is the apparent displacement of an object due to the motion of the observer. Tycho Brahe attempted to observe the parallax of a supernova (1572) and a comet (1577) and in both cases was unable to determine any change in apparent position of these objects compared to the background stars. From this he was able to conclude that they must be very far away. This provided crucial evidence that the "fixed stars" may not be so fixed!

Ch. 4 #14

The foci of an ellipse are the two points from which the sum of the distances to any point on the ellipse remains constant. If the Sun is at one focus, there won't necessarily be anything at the other focus. Not every mathematical artifact has significance in the physical world.

Ch. 4 #15

Kepler's Laws are 1: The planets orbit the Sun in the form of an ellipse with the Sun at one focus, 2: A line joining a planet and the Sun sweeps out an equal area in equal time, and 3: The square of a period of a planet's orbit is proportional to the cube of the semi-major axis of the orbit. Kepler's Laws are important because they are simple and accurate, supporting the Copernican view of the solar system. They combine theory with observation and they paved the way for Newton to eventually derive a theory of gravity.

2 Ch. 4 #19

Knowing the period, we can use Kepler's Law to find the simi-major axis, which is equal to the average distance from the Sun.

$$a = P^{2/3} = (125yrs)^{2/3} = 25AU$$

The clever approximation is to use the fact that the comet is on a highly elongated orbit around the sun. This means that the distance at perihelion is negligible compared to the distance at aphelion. Therefore we can approximate the distance at aphelion to be the length of the major axis: 50AU.

3 Ch. 4 #21

See figure 4-14 in the text. Anytime we notice a "full" Venus, it must be far away from us on the other side of the sun, thus far away with a smaller angular diameter. Likewise, anytime we notice a "new" Venus, it will be closest to us, and thus have a larger angular diameter.

Ch. 4 #22

Newton's Laws are 1: An object remains at rest, or moves in a straight line at a constant speed, unless acted upon by a net outside force, 2: F=ma, and 3: Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object. Examples 1: I remain at rest in my chair until a friend comes and pushes me off, 2: The force my friend uses to push me off is directly proportional to the acceleration I obtain falling out of the chair. The larger my mass, the smaller the acceleration and the smaller my mass, the larger the acceleration (for a given force).

Ch. 4 #23

Since F=ma, we can calculate:

$$F = 3kg * 2m/s^2 = 6N$$

If you double the force, the acceleration will double to 4 m/s^2, since force is directly proportional to acceleration.

Ch. 4 #24

Weight is a force and mass is a measure of the total amount of material in an object. Weight and mass are proportional, however, by Newton's second law. The proportionality constant is the value of g, which is the acceleration due to gravity for the object upon which you are standing.

4 Ch. 4 #27

Look at the universal law of gravitation and notice that the force is inversely proportional to the square of the distance separation the two objects. If you were to plug in a very large value for the distance, there would still be a force, albeit a very small one. The distance at which you'd escape the gravitational field of an object is actually infinite!

Ch. 4 #30

A tidal force is a gravitational force whose strength and/or direction varies over a body and thus tends to deform the body. Tides are produced with the earth's oceans because the moon (and the sun) is pulling harder on the side of the earth closest to it than the side away from it. This difference if force, called a tidal force, is what causes all that deformable material on the earth (water) to rearrange itself regularly to account for the various push and pull due to the moon. See figure 4-25 in the text.

5

(a) The force of a 10kg brick on the earth can be found by:

$$F = mg_{earth} = 10kg * 9.8m/s^2 = 98N$$

(b) On Mars, we know that the surface gravity is only 0.38 times that of the Earth, so:

$$F = mg_{mars} = 10kg * 0.38 * 9.8m/s^2 = 37N$$

The mass is still 10kg, no matter where you are.
(c) If someone drops a 10kg brick on your foot on Mars, it will hurt less than it would on the Earth because Mars's gravity pulls the brick down with less force on your foot.
(d) Since gravity is a force acting in the vertical direction only, the brick thrown horizontally will hurt the same no matter what the surface gravity is.

6

(a) Using Newton's Law of Gravity, we estimate that each person has a mass of 75 kg and that a distance of 0.5 m separates them. Even though they are both under the force of gravity due to the Earth we are only interested in the gravitational force of attraction between the two people:

$$F = \frac{Gm_1m_2}{r^2} = (6.67 * 10^-11 Nm^2/kg^2) * \frac{75kg * 75kg}{(0.5m)^2} = 1.5 * 10^{-6}N$$

This is equivalent to $3.4*10^{-7}$ lbs, using the same conversion fact we used earlier.

(b) The gravitational force between you and the earth can be found either with the equation above or with F=mg. The fact that you get the same answer is part of the beauty of Newton's Law of Gravity: the force that causes the planets to orbit the sun is the same as the force that keeps you bound to the Earth's surface.

$$F = mg = 75kg * 9.8m/s^2 = 735N$$

(c) There are a number of ways to do this. The easiest way is to use Newton's Law of Gravity. We use the mass of Deimos and an approximation of the size (~12 km) from Appendix 3:

$$F = 6.67 * 10^{-11} Nm^2/kg^2 * \frac{75kg * 1.8 * 10^{15}kg}{(6 * 10^3 m)^2} = 0.25N$$

0.25 N is roughly the same as 0.06 lbs.

7

This problem was mistakenly taken from last winter's course, when Venus was the "evening star". Right now, Venus is actually rising before sunrise as the "morning star", which means it won't be visible in the manner suggested in the problem. If you really want to see Venus you can get up 30 min before sunrise and look to the east on a clear morning. Although you can't see it with your eyes only, can you guess what phase you would observe?