Homework #5 Solutions
Astronomy 10, Section 2
due: Wednesday, October 5, 2011

Chapter 5; Problems 1,2

1) Compared with the strength of the Earth's gravity at its surface, how much weaker is gravity at a distance of 10 Earth radii from the Earth's center? At 20 Earth radii?

At the surface of the Earth, the gravitational force is:

$$F_E = \frac{GmM_E}{R_E^2}$$

where m is your mass. At a distance of 10 Earth radii, the gravitational force is:

$$F = \frac{GmM_E}{(10R_E)^2} = \frac{GmM_E}{100R_E^2} = \frac{1}{100}F_E$$

or, 100 times weaker than at the surface.

Likewise, 20 Earth radii away from the center of the Earth, the gravitational force will be 400 times weaker (note that $400=20^2$).

2) Compare the force of lunar gravity on the surface of the Moon with the force of Earth's gravity at Earth's surface.

We take the ratio of the two forces and do some algebra to reduce it to a simpler fraction. Note that your mass and the gravitational constant cancel out of the equation:

$$\frac{F_E}{F_M} = \frac{\frac{GmM_E}{R_E^2}}{\frac{GmM_M}{R_M^2}} = \frac{M_E}{M_M} \times \frac{R_M^2}{R_E^2} = \frac{5.98 \times 10^{24}}{7.35 \times 10^{22}} \times \frac{\left(1.74 \times 10^3\right)^2}{\left(6.38 \times 10^3\right)^2} = 6.1$$

Plugging in the masses and radii of the Earth and Moon (from Table A-5 of textbook) allows you to calculate the ratio. The result tells us that you'd feel 6 times the force of the surface of the Earth than you would on the surface of the Moon. You'd weigh 6 times less on the Moon than on Earth.

Chapter 5; Learning to Look 1, 2

1) Why can the object pictured be bolted in place and used 24 hours a day without adjustment?

The satellite dish is used to communicate with a satellite. It can be bolted down if the satellite is always in the same position in the sky. This can be achieved by putting the satellite at an altitude where the velocity required to keep it in uniform circular motion around the Earth results in an orbital period that exactly matches the Earth's spin. This is called a geosynchronous orbit.

2) Why is it a little bit misleading to say that this astronaut is weightless?

The astronaut is in the space shuttle. As he flies in the space shuttle, the mutual gravitational attraction between the Earth and the shuttle keeps the shuttle in orbit. We generally use the word "weight" to refer to the gravitational force. Here, the astronaut is effectively in free fall. Therefore, there is no floor to push back on his feet and he feels weight-less even though there is certainly a gravitational force acting on him. It is OK to say that the astronaut is experiencing weightlessness. What's most important is to realize that the weightlessness is a result of free-fall and NOT the result of the increased distance from the center of the Earth -- a common misconception.