Phys122

HW 8: Due Thursday, April 13, 2006

Problems Chapter 22:

6, 8, 22, 28, 32, 40, 56, 60

Measuring the speed of light a la Galileo

Galileo tried to measure the speed of light by having two people stand on hills about 5 km apart. Each would hold a shuttered lantern. The first would open his lantern and when the second saw the light, he would open his lantern. The first person would then measure how much time it took between the time he first opened his lantern and when he saw the light returning.

a. How much time would it take the light to travel between the two hills?
b. Is this a good way to measure the speed of light? Support your argument with a brief explanation that includes some quantitative discussion of the uncertainty in the measurement.

Speed of light and the GPS system

Although light appears to travel at a speed that is for all practical purposes infinite, for some modern purposes the time delay due to light travel time is of great importance. The Global Positioning System (GPS) allows you to determine your position from comparison of the time delays between radio signals from 4 satellites at a height of 20,000 km above the surface of the earth. (There are actually 24 of these satellites. Your GPS picks out the closest 4 to your current position.) In order to get some idea of how important the speed of light is in establishing your position with one of these gadgets, let's make some simple assumptions. Assume a satellite is almost directly overhead. Then let's figure out how far the satellite will move in the time it takes light (the radio signal) to get from the satellite to your GPS receiver. This estimates how far off the reading of your position would be if your device didn't include the speed of light in its calculations. To do this:

a. Assuming that the satellite is in geosynchronous orbit (at same point above the earth's surface at all times) at a radius r = 4.23*10^7 m, figure out at what speed the satellite must be going.
b. Estimate the time it would take for a radio signal to get from the satellite to your receiver.
c. Estimate how far the satellite would move in that time. If you ignored light travel time, this tells about how wrong you would get the satellite's position (and therefore how wrong you would get your position).