How fast are you moving?

Imagine for a moment that you are standing on the equator of the Earth. As the Earth rotates you are moving around a circle with a circumference of about 24,901 miles in 23 hours and 56 minutes. A bit of math reveals that moving that distance in that much time equals a velocity of 1037 mph. On the other hand, if you are standing at the either pole you are not moving at all so your velocity is 0 mph. From this you can deduce that the velocity you're moving on the surface on the surface of the Earth as it rotates varies with latitude. In this exercise we will explore this relationship and some of its implications.

In order to proceed we must first know how to calculate the distance around the Earth at a given latitude. The formula for the distance around a planet (D)at a given latitude (L) with an equatorial diameter (E) is D=cos(L) x E. For the Earth E=24907.55 miles.

Example 1
What is the diameter around the Earth at 40^{o} N?
D=cos(L) x E
D=cos(40^{o})x24,901.55 miles
D=0.766x24,901.55 miles
D=19,074.59 miles

Would your answer be any different for 40^{o} S? _____

Remember that velocity (v) equals distance (D) divided by time (t). (v=D/t). It takes the Earth 23 hours 56 minutes to complete one rotation. So as the Earth rotates we are traveling the distance at any given latitude in 23 hours 56 minutes (23.93 hours)

Example 2
How fast are you moving at 40^{o} N as the Earth spins?
v=D/t
v=19,074.59 miles/23.93 hours
v=797mph

Why did we use 23 hours 56 minutes as opposed to 24 hours?

_____
_____
_____

If we combine the formula for D and for v we can arrive at a formula for velocity at a given latitude.

V=(Cos(L)xE)/t

Example 3
How fast are you moving as the Earth Spins at 35^{o} S?
V=(Cos(L)xE)/t
V=(Cos(35)x24,901.55 miles)/23.93 hours
V=(0.819x24,901.55 miles)/23.93 hours
V=(20,394.37 miles)/23.93 hours
V= 852.25 mph.

Your assignment today is to write a spreadsheet. This spreadsheet should:

- Allow the user to input an equatorial circumference and a period of rotation for any planet or moon.
- The spreadsheet should display a chart showing the velocity for every 10 degrees of latitude.
- The spreadsheet should contain a graph showing how velocity relates to latitude.
- The spreadsheet should contain an area where the rotational velocity can be calculated for any latitude on any planet or moon.
- Think about what units other than mph you might want your spreadsheet to report velocity in.

(also keep in mind that Excel uses radians for its trig functions so you'll need to use the RADIANS function to convert degrees to radians)

Once your spread sheet is written please answer the following questions. You may need to use Google Earth to get the latitudes you need (note: make sure you've set it to display latitude in decimal degrees and not degrees, minutes, seconds.) The following web site WILL be helpful http://www.nasm.si.edu/etp/ss/ss_planetdata.html. Keep in mind you may need to convert units.

When you've written you spreadsheet please e mail it to me. You may either e mail of give me a hard copy of the following questions.

1) The rotational velocity of the Earth can be used to give rockets a "boost" as they go into orbit. How much more added velocity might a rocket get by being in Key West (the farthest south point in the USA) as opposed to Cape Kennedy?

2) The Russians launch their rocket from Star City right outside of Moscow. What is the rotational velocity there?

3) Given your answers to 1 and 2 do you think rotational velocity is the only consideration when deciding where to launch rockets from? If not what other considerations might there be? How might these considerations have varied between the US and Russian space programs?

4) How fast is Jupiter spinning at its Equator?

5) Jupiter's Equatorial radius is far larger than its polar radius. Why?

6) How fast are you spinning on the equator of Mercury? _____ Venus? _____

7) There is very little, if any, difference between the equatorial and polar radii of these planets why?

8) Now consider the difference between the equatorial and polar radii of the Earth and Mars. Why do the Earth and Mars show some "flattening" where Mercury and Venus don't.

Why don't the Earth and Mars show as much as Jupiter?