Time Dilation

It is strange but true that if you are moving, time slows and mass increases.

One of the amazing results of Einstein's work in relativity was that we have a better understanding of how time and space are related. And that time is actually relative to the observer.

Why is it important? Since these effects are only really noticeable as your speed gets really fast, it is not perceived by you when you drive a car or even fly in a plane. The effect becomes measurable when you start going really fast for a long period of time. GPS satellites all have a built in atomic clock that is accurate to 1 nanosecond (1 billionth of a second). Amazingly, these clocks will read a different time than the ones on Earth. Because the satellites are moving relative to the Earth observers, they will appear to run slower. But because time is also dilated by gravitational fields, the Earth observers will be affected more than the satellites and the GPS clocks will appear to speed up. This is the bigger effect and the cumulative relativistic effects cause the GPS satellite to run faster than the clocks on Earth. In order to be truly accurate, this must be corrected in the GPS system. This actually equates out to an error of about 38 microseconds a day. This is very significant for GPS accuracy. If this were not accounted for, the GPS system would be off about 10 kilometers a day.

Can this time difference be predicted? Absolutely. The equation that gives us a value for the dilation factor is:

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

where *v* is the object speed relative to an observer and *c* is the speed of light.

Let's use this to calculate how much younger the first Martians will be when they arrive on planet. For a proposed mission to Mars, the astronauts will be traveling at 26.5 km/s and it will take about 220 days to get there. The speed of light is roughly 300,000 km/s. Let's calculate the time dilation factor.

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{26.5^2}{300000^2}}} = \frac{1}{\sqrt{1-7.802\ x\ 10^{-9}}} = \mathbf{1.0000000039}$$

So time will appear to us as 1.000000004 times longer than the people on their way to Mars. Is this a problem? Let's calculate how long that is.

$$220\ days\ x\ 1.000000004 = \mathbf{220.00000085}\ \boldsymbol{days}$$

Let's convert the difference into seconds.

$$0.00000085\ days\ x\ 24\frac{hours}{day}\ x\ 3600\frac{sec}{hour} = \mathbf{0.073}\ \boldsymbol{seconds}$$

So after traveling at 26.5 km/s for 220 days, the astronauts will only be 73 thousandths of a second younger than their loved ones on Earth.