Name: ____________
Section: ___________

December 21, 2012: Are we all going to die?

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Over the past few years, websites, books, and even a big blockbuster movie have popped up concerning the ancient Mayan "prediction" that the world will end on December 21, 2012. It is true that the 13th bak'tun of the Mayan calendar will end on December 21, 2012. So what?, the 12th month of the modern calendar ends on December 31 every year. However, the end of the 13th bak'tun is supposed to be a special occasion (similar to the year 2000 was for us, or the last year of a decade).

If that was the end of the claims proposed by these websites, books, and movies, then we could just leave it up to the historians, anthropologists and archaeologists to deal with the myths. Unfortunately, the 2012ers (all conspiracy theorists need an "ers" behind their collective name) decided they'd make a few claims pertaining to *how* the world is going to end. These claims delve heavily in the pseudo-science astrology (the study of how the stars and planets affect our daily life). We will take a look at a couple of these claims, namely the claim that a planetary alignment will destroy the Earth and the claim that a previously unseen planet will destroy the Earth.

Forces of Planetary Alignment

For centuries, astrologers have "known" that planetary alignments are times of great stress and disaster, so it's no surprise that it's put forward by 2012ers as one of the ways the world will end. However, no astrologer has ever come up with a scientific theory or any evidence concerning why planetary alignments are such an issue, but let's take a look at it anyway. There are four different ways that matter can interact: gravitationally, electromagnetically, and through the weak and strong nuclear forces. The two nuclear forces only work for nuclear distances, so we can drop those from consideration. The planets have no net electric charge, but some of them (including Earth) have magnetic fields. Could they be interacting? Well, no. The magnetic fields of the planets are incredibly weak, and the distances between the planets so large that they have no effect. The Sun's magnetic field interacts with the Earth's, but that won't change if you have planetary alignment.

This leaves one force to analyze, gravity. Keep this question in mind as you do this part of the lab exercise: can the gravity distribution in a planetary alignment change the Earth's orbit?

Given in the table below is the mass of 8 bodies in the solar system (the Sun and the planets that aren't Earth). Also given is the distance from Earth to these different bodies when the planets are all aligned.

Body	Mass (g)	Distance (cm)	Distance^2 (cm^2)	Force (dynes)
Sun	1.99×10^{33}	1.50×10^{13}		
Mercury	3.30×10^{26}	9.12×10^{12}		
Venus	4.87×10^{27}	4.14×10^{12}		
Mars	6.40×10^{26}	7.84×10^{12}		
Jupiter	1.90×10^{30}	6.29×10^{13}		
Saturn	5.69×10^{29}	1.28×10^{14}		
Uranus	8.70×10^{28}	2.72×10^{14}		
Neptune	1.03×10^{29}	4.35×10^{14}		

In the table above, calculate R^2 and F for each body. The force of gravity between a body of mass M and the Earth is $F_{grav} = (3.98 \times 10^{20})\left(\frac{M}{R^2}\right)$ (R is the distance from the Earth to that body when the planets are aligned)

By following the steps below and using the values you found previously in the table, calculate the net force on the Earth from the Sun and all its planets to **5 significant figures** (i.e. $1.2345\times10^{\text{something}}$)

The sum of the gravitational forces on the Earth in the direction of the sun is:

$$F_{inside} = F_{Sun} + F_{Mercury} + F_{Venus}$$

F_{inside} = ____________________ dynes

The sum of the gravitational forces on the Earth in the direction opposite the sun is:

$$F_{outside} = F_{Mars} + F_{Jupiter} + F_{Saturn} + F_{Uranus} + F_{Neptune}$$

$F_{outside}$ = ____________________ dynes

The net force on the Earth from the Sun and all the planets is:

$$F_{net} = F_{inside} - F_{outside}$$

F_{net} = ____________________ dynes

The net force looks like this because force is a vector, requiring a magnitude and a direction. The Sun, Mercury, and Venus are on one side of the Earth when total alignment occurs, and Mars, Jupiter, Saturn, Uranus, and Neptune are on the other.

You may be thinking "Isn't F_{net} just the force of gravity between the Sun and the Earth that I calculated in the table above?" Well, not quite, but it's pretty darn close! (Hint: that's why I told you to go to 5 significant figures). Anyway, let's see how close the two values are.

$$\frac{F_{net}}{F_{Sun}} =$$ _____________ (again, calculate to 5 significant figures)

With that in mind, during alignment, is there a significant difference in the gravitational force on the Earth from the Sun and the net gravitational force between the Earth and everything else? _____________

Since the orbit of the Earth is based on the gravity between the Sun and Earth, what effect (if any) do you think this would have on the orbit of the Earth? ______________________

Tides

Now, you might be thinking there's a lot of force on both sides of the Earth. Could that rip it apart!? ... Without getting into too much detail, the answer is no, because the forces you calculated are the forces on the whole Earth, not just part of it. For example, Jupiter pulls on every part of the Earth, not just the side it's closest to. Because of the difference in distance between the near side of the Earth and the far side, there's a difference in forces on both sides of the Earth. These are what we call tides, but the tides caused on Earth by the planets aren't even measurable.

What body in the solar system causes the most tidal force on Earth? __________

What other body/bodies in the solar system cause a significant and measurable tide on the Earth? _________

Planetary Configurations
Now that we've seen that planetary alignment doesn't do anything to the Earth, let's see if there's actually going to be a planetary alignment as the 2012ers claim. On the next page, you have the planetary configuration from the day the United States declared independence on (July, 4 1776). You will draw the planetary configuration on December 21, 2012 on the other set of circles.

The orbital periods of the inner planets are:
Mercury: 0.241 years per orbit
Venus: 0.615 years per orbit
Earth: 1.00 year per orbit
Mars: 1.881 years per orbit

If July 4th was the 185th day of 1776, and December 21st is the 355th day of 2012, how long is the time between them? _______________ years (put your answer in the form 123.456 years)

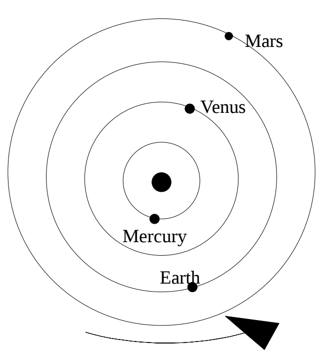
It might be easier if you put the dates in terms of only years. For example, the first day of spring this year is March 20, 2010. March 20 is the 79th day of the year 2010. $79\ days = 79\ days\left(\frac{1\ year}{365\ days}\right) = 0.216\ years$

So, March 20, 2010 is 2010.216 years.

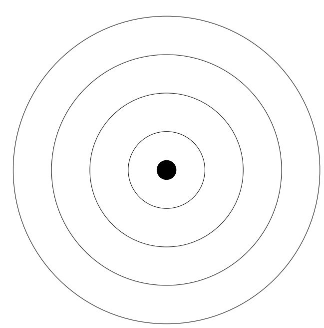
Now, find how many orbits each planet has made in that time by dividing the number of years you just found by the period. (give me 3 decimal places)

Mercury: __________________ orbits
Venus: __________________ orbits
Earth: __________________ orbits
Mars: __________________ orbits

July 4, 1776



December 21, 2012



In order to find where the planet is on its orbit, you can drop the digits to the left of the decimal point (<u>123</u>.456 becomes <u>0</u>.456 for example) and this tells you how far through the most recent orbit your planet is. For example, if my planet has completed 123.456 orbits, it has completed 123 full orbits, and it's 0.456 orbits into the 124th orbit. Using this knowledge, and the knowledge that from this view, the planets orbit the Sun **counter-clockwise**, you can plot where Mercury, Venus, Earth and Mars will be on December 21st 2012.

Will there be a planetary alignment on December 21, 2012? ____

<u>OH NOES! IT'S GOING TO HIT US!!!!!</u>

The 2012ers claim there's a "thing" out there that is orbiting the Sun, that's going to come close to us on December 21, 2012 which will come close enough to the Earth to gravitationally affect its orbit so much that we would all *die*. I say "thing" because I couldn't find a definite consensus on what it is. It could be a white dwarf, neutron star, brown dwarf or a planet. To demonstrate my point most effectively, let's look at the dimmest of these objects, a planet.

In the study of the solar system, there's a system of measuring brightness called the heliocentric absolute magnitude (H). It's basically a measure of how bright an object would look if you were standing on the Sun and the object were in Earth's orbit, and it's a way to standardize the brightness of objects so we can compare different objects that are at different distances. If we know H for an object and how bright it looks to us (called the apparent magnitude, m), then we can find the distance to it, using the relation:

$$d = 10^{\left(\frac{m-H}{10}\right)}$$ (d has units of AU)

In clear skies, someone who has good eyesight can see an object with apparent magnitude less than m=6.5 (magnitudes are kind of weird in that smaller numbers are brighter, the Sun has an apparent magnitude m = -27).

The Hubble Space Telescope can see an object with apparent magnitude less than m=31.5

How far away would our Earth-killing planet (H=-8.5) be if we could just barely see it with our eyes (in other words, m=6.5)? ____________ AU. For reference, Neptune orbits the Sun at ~30 AU.

How far away would it be if the Hubble Space Telescope could just barely see it? __________ AU

If there is a killer planet out in the Solar System that will hit us in 2012, do you think we would know about it? <u>Why or why not</u>?