Name: ______________________________ Pledged: ________________________________

PHYS 1304 Midterm 1

This test consists of 10 short answer questions plus extra credit. You have 50 minutes to complete the test. Partial credit will be given on problems. Questions left blank receive no credit. Questions that give incorrect or unrelated information will also be marked down. Tell me the the right answer, not just everything you know.

1. You fell asleep in class again. Of course, it really was the professors fault for giving such big assignments. Apparently your professor doesn't see it that way because once again you wake up to find yourself in the middle of nowhere. With little else to do, you watch the sky to get some indication of where you are. The first thing you notice is that you don't recognize any constellations and can't seem to find Polaris at all. Some other things stand out as well. Virtually no stars ever set, including the Sun. The Sun goes from right on the horizon on one side of the sky to about 20 degrees above the horizon on the other side, but never completely sets. Tell me everything you can about where you are and roughly what time of year it is.
The short answer is that you are inside the Antarctic circle and it is near the southern summer solstice. How do you know this? First, you can't see Polaris so you are south of the equator. Since nearly everything is circumpolar you have to be fairly close to a pole. The fact that the Sun never sets means you must be inside the Antarctic circle. Also, the fact that the Sun never sets tells you that it is summer down there.

2. One of the things that makes Pluto stand out as different from the other planets is that its orbit has a fairly high eccentricity of 0.25. Given that the semimajor axis of Pluto is 39.5AU, what is the closest it ever gets to the Sun and what is the farthest it ever goes from the Sun?
Closest distance = a*(1-e), farthest distance = a*(1+e)
For this problem a=39.5AU and e=0.25.
So we get a closest distance of 39.5AU*(1-0.25)=39.5AU*0.75=29.6AU
For furthest distance we get 39.5AU*(1+0.25)=39.5AU*1.25=49.4AU
Some people converted to km which is still correct, but in this case isn't required because I don't specify units.

3. What are the 3 hallmarks of science?
This is straight from page 79 of your text.
a. It explains observations using natural causes.
b. It creates models and tests them. That models should explain observed phenomena as simply as possible.
c. The models must make testable predictions that force the model to be revised or discarded when the observations disagree with the predictions.

4. The two primary motions of the Earth in our Solar System are rotation about the Earth's axis and revolution about the Sun in our orbit. How are these motions manifest in what we see in the sky?
The spin of the Earth is the reason everything rises in the east and sets in the west. If the Earth did not spin on its axis the Sun, moon, planets, and stars would not take their daily voyage across the sky. Indeed, the stars wouldn't move at all other than on the incredibly slow timescale of their drift through the sky that alters constellations. The moon would circle around on the timescale of a month and the Sun would take a full year to go from noon to noon on any particular place on the globe.

The revolution of the Earth about the Sun leads to the fact that the Sun moves through the background stars along the ecliptic. If the Earth didn't orbit the Sun, we would always see the Sun in the same position relative to the stars. Since you can't see stars that are very close to the Sun, this would mean that a certain set of stars would remain forever hidden from human view. Equivalently, it is this motion that causes you to see different constellations at night over the course of the year.

Some people mentioned apparent retrograde motion. This does require the motion of the Earth orbiting the Sun. However, it also requires the motion of the other planets orbiting the Sun at different speeds. If this was the only motion you mentioned for the Earth's orbit a few points were deducted.

5. On a camping trip you and your friend go out into the hill country for some dark skies and a little amateur observing. The night sky is crisp and clear and you happen to spot Saturn in the telescope. The image is really breathtaking and your friend remarks on how cool it is to just see the planet hang there in the middle of nothing, not moving. Having taken astronomy you respond that it most certainly is moving. You tell your friend it is orbiting the Sun at a high rate of speed. Your friend

asks you for details, but unfortunately, the only things you have with you are a chart telling you the semimajor axes of the planets and a calculator. The chart tells you that the semimajor axis of Saturn is 9.5AU. Using this, figure out for your friend how long it takes Saturn to orbit the Sun in years.

For this one you use Kepler's 3rd law: $p^2=a^3$. You are given a so we have $p=a^{1.5}$ for a=9.5AU.

$P=9.5^{1.5}=29.3$ years

6. Your friend isn't convinced that Saturn's motion in its orbit is all that fast. After all, you are talking years to get around the Sun. Use your answer from the previous question to figure out how fast Saturn is moving in its orbit in km/h. Assume a circular orbit to keep things simple.

This is our standard speed calculation of distance divided by time. The only trick is that we have the units in AU/year and we need to convert to km/h.

$$\frac{2\pi\, 9.5[AU]}{29.3[yr]}*\frac{1[yr]}{365[days]}*\frac{1[day]}{24[h]}*\frac{1.5*10^8[km]}{1[AU]}=\frac{9*10^9[km]}{2.6*10^5[h]}=3.5*10^4[km/h]$$

7. As you sit in Mabee eating dinner, a friend comes up and shows you a tabloid that was recently purchased from a grocery store line. Your friend, knowing you are enrolled in astronomy, eagerly flips to a story that says that astronomers using the Keck telescope had just found evidence of a missing space probe in the Andromeda galaxy. How do you explain to your friend that this story is complete non-sense? (Hint: it isn't the missing probe part, that has happened a few times.)

The explanation focuses primarily on how far away the Andromeda galaxy is. You don't have to know the exact number. If you just remember that our galaxy is over 100,000 ly across, you know any other galaxy has to be more than that far away. This leads to some problems. First, our space probes don't travel very fast and would take absurdly long periods of time to travel that far. No probe has even come close to the distance to the nearest star, let alone another galaxy. Even if somehow the probe were teleported to the Andromeda galaxy, it would take light/signals from the probe hundreds of thousands of years to get back to Earth. That's a bit longer than the few decades we have been launching probes.

There are some other problems dealing with observing a probe at that distance, but you weren't expected to put these because we haven't learned about telescopes yet. We have no chance of resolving whole planets at that distance. Seeing a probe is completely out of the question. Now probes do emit radio waves as part of our communication with them. However, Keck is a visible/IR telescope and can't see these. That type of observation would have been done with radio telescopes like VLA or VLBA.

8. For this problem we will consider the star HD72659, which has a planet in orbit around it. The planet orbits the star at a distance of 4.5 AU. The system is 168 ly from the Earth. What is the maximum angular separation between the star and the planet as seen from Earth?

This question is asking about angular separation. We have only learned of one formula for dealing with that, so that is what we will use.

$$\frac{physicalSize}{2\pi*distance}=\frac{angularSize}{360^o}$$

The only challenge in this question is that you have been given the distances in different units. To make things work out you have to convert them to the same units.

$$physicalSize=4.5[AU]*\frac{1.5*10^8[km]}{1[AU]}=6.75*10^8[km]$$

$$distance=168[ly]*\frac{9.46^{12}[km]}{1[ly]}=1.59*10^{15}[km]$$

We can do a little rearranging and plug these in to get the answer.

$$angularSize=\frac{360^o*6.75*10^8[km]}{2\pi*1.59*10^{15}[km]}=\left(\frac{2.43*10^{11}}{10^{16}}\right)^o=(2.43*10^{-5})^o=0.087[arcseconds]$$

The last step isn't required since I didn't explicitly ask for arcseconds, but it can be nice to help make sense of our result.

9. One of the challenges in coming up with a proper calendar for humans to use is that the tropical year isn't the same as the sidereal year. What do these terms means and how are they different?

The tropical year is the length of time it takes the Earth to get back around to the same position relative to the Sun. For example, the time between one vernal equinox and the next. The sidereal year is how long it takes the Earth to get around the Sun to the same position relative to the stars. So it could be the length of time between when a certain star is at opposition from one time to the next. These two are different because of the precession of the precession of the Earth's spin axis.

10. How were the roles of Kepler and Brahe in the Copernican revolution linked? Why could neither have played a significant role without the other?
Brahe was a great observer who collected a large database of observations of the locations of the planets. Unfortunately, he wasn't able to do much with this information. That was in part because of his untimely death but also because he had certain preconceived notions about the Universe that he didn't let go of and it is quite possible he lacked the mathematical skills to really take the next step.

Kepler had those mathematical skills, and was willing to break free of the classical notions of the organization of the Universe. Without Brahe's data and a strong faith in the quality of that data, he wouldn't have been able to make the contribution that he did.

Extra Credit: One of the things that Copernicus favored about his model was that it allowed him to calculate the orbital periods of the planets. Assume a body that is observed to take 1.2 years between oppositions. What is the orbital period of this body?

$$P_{orb}=P_{syn}\frac{1[yr]}{P_{syn}-1[yr]}=1.2[yr]\frac{1}{0.2}=6[yr]$$