Observational Cosmology: Homework No.1

*Student ID:*_____ *Name:*_____

A. Short questions

1. Fill in your answers in scientific notations:
   _____ arcseconds = 1 degree
   _____ km = 30 ly
   2 ly + 1000 km = _____ km

2. The nearest large galaxy to our own is about 2 million light-years away, how many meters is that? How many galaxies like our own would it take laid edge to edge to reach the nearest galaxy?

3. If light takes 8 minutes to reach the earth from the sun and 5 hours to reach Pluto, what is the distance (expressed in [AU]) from the sun to Pluto?

4. A marble has a diameter of 2 cm. At what distance would the marble have an angular diameter of 1 arc second?

5. The angular diameter of the Moon is $0.5^\circ = 30$ arcminutes $= 1800$ arcseconds. A 10-cent coin is approximately 2 centimeters in diameter. How far away from your eye must you hold the coin in order for it to subtend the same angular diameter as the Moon?

6. The Earth has a diameter of 12700 km. The Moon's diameter is 3500 km. What is the angular size of the Earth as seen by an astronaut standing on the Moon? Note that you have already learned the angular size of the Moon as seen from the Earth.

7. What time in a day does a full moon rise? Draw a simple sketch and explain for it.

8. Why have more people seen total lunar eclipses than total solar eclipses?

9. You are dropped onto an unknown location on Earth. Cleverly, you note that Polaris is about 30° above the horizon. What's your longitude?

10. On what day of the year is the noontime Sun directly overhead for observers at latitude 23.5 degrees north of the equator?

11. Why isn't the winter solstice the coldest day of the year?

12. Neptune (currently the most distant planet from the Sun!) lies about 4.5×10^9 kilometers from the Earth. If you were traveling toward Neptune at typical highway speeds (about 100 kilometers/hour), how many years would it take to reach Neptune?

13. The position of a star in the sky can be defined by its location relative to stars at very large (can be taken as infinite) distances. Suppose you observe the position of a nearby star today and find that it is shifted by an angle of $2p$ relative to its position six month ago. How is the distance of the star related to its parallax p (assuming $p \ll 1$ radian)? The distance corresponding to $p = 1$ arcsecond is called one parsec, or 1 pc. How many meters is equal to 1pc?

14. What are Arctic Circles, Antarctic Circle, Tropic of Cancer, and Tropic of Capricorn? How are they defined?

    Suppose there is another earth, whose rotation axis is in its orbital plane around the sun, i.e. its rotation axis is tipped at 90° with the norm of the orbital plane. (1) Where would be the Arctic Circles, Antarctic Circle, Tropic of Cancer, and Tropic of Capricorn on the globe of such an earth? (2) Suppose your latitude is 45° north on the surface of this earth. How would your daytime changes during the course of a year starting from vernal equinox, to summer solstice, to autumnal equinox, to winter solstice, and back to vernal equinox?

B. Questions that need more thinking

1. Kepler's Third Law of planetary motion relates the time, T, it takes a planet to complete one orbit about the Sun to the distance, a of that planet from the Sun via $T^2 \propto a^3$.

   (1) Use what you have learned to convert the proportionality into an equation.

   (2) Suppose that a planet is found to take 8 years to complete an orbit around the Sun. How far is this planet from the Sun?

   (3) Prove that the Kepler's Third Law implies that gravitational force between the Sun and a planet is proportional to the mass of the planet $m_{\rm P}$ and the inverse of a^2.

2. Suppose the Sun is located near the center of your zodiac constellation on your birth day.

   (1) How far away (in angular distance) is the Sun from the center of your zodiac constellation one month after your birthday?

   (2) After three months of your birth day, where should you look for your constellation at sunrise?

3. The Hubble Ultra Deep Field you saw in the lecture and the text book is a very deep image of galaxies located in a small area in the sky. Please use your imaginations and reasonings to answer the following two questions.

   (1) What kinds of physical quantities can you obtain from such an image? (Physical quantities means the intrinsic properties of an object)

   (2) What kinds of science questions can you address with the observational data?

4. Assume that the Earth's orbits around the Sun and the Moon's orbits around the Earth are all circular.

   (1) What are the main properties of the Earth's orbit around the Sun and the Moon's orbit around the Earth?

   (2) Explain how you can use these properties to predict the future solar eclipses, if these two orbits are in the same plane?

   (3) Answer the above question for the real case where there is an angle between these two orbital planes (this angle can be found in the textbook or online).