Astronomy 1143 Quiz 1 Review

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I What is Science?

1. Explain the difference between astronomy and astrology.

   - Astrology: nonscience using zodiac sign to predict the future/personality traits.
   - Astronomy: scientific study of planets, stars, galaxies, and the universe.
   - Science is testable, falsifiable, and observable!

2. What number is the metric system based around? What are some of the more widely used prefixes?

   - 10
   - milli-: 1/1000th, centi-: 1/100th, kilo-: 1000

3. What special attribute of certain constellations puts them in the zodiac?

   - They lie in the plane of the Sun's orbit around the Earth (the ecliptic plane).

II Observational Astronomy: The Night Sky

1. What is the ecliptic plane?

   - The plane of the Sun's orbit projected on the sky. Since all the planets have low inclination, it is also where they lie. The zodiac constellations are important because they are the ones that the sun and the planets move through across the night sky.

2. Why is the ecliptic tilted with respect to the celestial equator? How big is this tilt in degrees?

   - Because the Earth's rotation is tilted with respect to its revolution around the Sun.
   - 23.5 degrees.
   - It is because of this tilt that we have seasons.

3. Where does the ecliptic plane intersect the celestial equator?

   - The Vernal Equinox (0 degrees right ascension, 0 degrees declination)

4. What are the primary coordinates for finding a place on Earth? How about the celestial sphere?

   • Earth: longitude and latitude.
   • Celestial sphere: right ascension and declination.

5. In what constellation would you find Polaris?

   • Ursa Minor.
   • (The asterism you find Polaris in is The Little Dipper!)

6. What is the angular size of an object? What is it for the Moon? The Sun? Which is actually bigger? How do you reconcile this?

   • The angular size of an object is the angle subtended in your field of view by the object.
   • The moon is about 30' in the sky, as is the Sun.
   • The Sun is actually much larger than the Moon, but it is farther away, so it looks smaller across the sky than it should. The Moon is closer, and thus looks larger.

7. Why does the Moon have phases?

   • The angle between the Earth, Moon, and Sun dictates how much of the illuminated side of the Moon we see from the Earth.
   • During a New Moon, we only see the dark half of the Moon. This means the Moon is between the Earth and the Sun.
   • During a Full Moon, we see the illuminated half of the Moon. This means the Earth is between the Moon and the Sun.

8. Why do we not have an eclipse every month?

   • Because the Moon's orbit is tilted around the Earth, so the Earth-Moon-Sun line is not always aligned properly.

9. How big is an arcminute? An arcsecond?

   • $1'(' =$ arcminute) = 1/60th of a degree.
   • $1''('' =$ arcsecond) = 1/60th of an arcminute = 1/3600th of a degree.

10. What is stellar parallax? Why is it useful? Does a nearby star have a larger or smaller parallax than one that is farther away?

   • Stellar parallax is the apparent change in position of stars brought about by the motion of the Earth around the Sun.
   • It can be used to determine the absolute distance to stars.
   • A nearby star has a larger apparent motion in the sky, so it has a larger parallax. Think, a parked car right next to you passes by much more quickly as you jog than a parked car on the horizon!

11. Why couldn't the Greeks see parallax?

   • Even for the nearest star, the parallax is far too small to see with the naked eye.

12. What is a parsec? How many light years are in a parsec?

• A parsec is the distance an object must have from Earth to have a parallax of $1'' = 1$ arcsecond.
• 1 pc = 3.26 ly

13. How close is the nearest start to the Sun? What does this say about space?

• The nearest star is Proxima Centauri at 1.3 pc (4.2 light years).
• This means that most of the space in the galaxy is devoid of stars, since the distance between stars is much, much greater than their average size!

III The Heliocentric Model

1. In simple terms, what are the geocentric and heliocentric models?

• Geocentric: the planets and Sun all orbit around the Earth.
• Heliocentric: the planets, Earth included, all orbit around the Sun.

2. Who was the first major proponent of the heliocentric model? What were the key facets of his model?

• Copernicus.
• His model had a central Sun with the planets orbiting it. It also included epicycles, like Ptolemys geocentric model, to preserve circular motion.
• Epicycles are circles within circles, used to explain the strange motion of the planets across the sky, such as retrograde motion.

3. Explain the main observational problem that Mars presented for the Geocentric and early Heliocentric models.

• Retrograde motion: Mars would abruptly change its direction of motion on the sky and then flip back periodically.

4. What did Ptolemy add to the geocentric model explain this problem?

• By adding epicycles, i.e. circular orbits within circular orbits, to the planets' motion around the Earth.

5. Who correctly solved this problem? How? Using whose data?

• Johannes Kepler solved this by incorporating elliptical orbits rather than perfectly circular ones, compiled from Tycho Brahe?s data.

6. Which of Galileo's observations supported the heliocentric model?

• Phases of Venus.
• Satellites of Jupiter (something else in the solar system has objects orbiting it besides the Earth).

7. Define: superior planet, inferior planet, conjunction, opposition, quadrature, perihelion, aphelion, and eccentricity.

• Superior planet: one whose orbit around the Sun is outside that of the Earth?s.
• Inferior planet: one whose orbit around the Sun is internal to that of Earth?s.
• Conjunction: occurs when the Sun is directly between the Earth and a superior planet, an inferior planet is between the Earth and the Sun (inferior conjunction) or the Sun is between an inferior planet and the Earth (superior conjunction).
• Opposition: occurs when the Earth is directly between the Sun and a superior planet.
• Quadrature: occurs when the Sun and a superior planet are 90 degrees apart.
• Perihelion: the closest a body comes to the Sun in its orbit.
• Aphelion: the farthest a body gets from the Sun in its orbit.
• Eccentricity: a measure of how much a 1 sided object deviates from being a perfect circle. Is 0 for a circle, 1 for a straight line, and determined by the ratio of semiminor to semimajor axis.

8. Venus is on the opposite side of the Sun compared to the Earth. What is the name for this configuration of an inferior planet?

   • Superior conjunction.

9. What is a synodic period of a planet? Sidereal period?

   • Synodic period: time it takes for a planet to return to the same spot on the night sky. Similar to "solar day".
   • Sidereal period: time it takes for a planet to return to the same spot in its orbit around the Sun with respect to a fixed observer (the stars).
   • Think sidereal is the ?real? period. For planets all orbiting in the same direction, a synodic period will always be slightly longer than the sidereal period of the inner of the two planets.

10. Are planetary orbits perfectly circular as proposed by Copernicus?

   • No, they are on elliptical orbits.

11. Explain Kepler's 3 Laws.

   • 1st Law: All the planets are on elliptical orbits, with the Sun at one of the foci.
   • 2nd Law: In their orbits around the Sun, every planet sweeps out equal area in equal time. This means when it is closest to the Sun, it moves the fastest.
   • 3rd Law: The square of the period of any orbit is proportional to the semimajor axis of the orbit to the third power.

12. What is the proportionality between period and semimajor axis in Kepler's 3rd Law?

   • Period squared is proportional to the semimajor axis cubed.

13. Verify Kepler's 3rd law: a planet orbits the sun at 4 AU, and has a period of 8 years.

   • In solar system units, the Earth has a period of 1 year at 1 AU from the Sun, according to Kepler's 3rd law, $\frac{(1year)^2}{(1AU)^3} = 1year^2/AU^3$. For the planet which has a period of 8 years at 4 AU, by Kepler's 3rd law, $\frac{(8year)^2}{(4AU)^3} = 1year^2/AU^3$, which agrees with the result of the earth. Thus Kepler's 3rd law is valid.

IV Newton and Motion

1. What are Newton's 3 Laws of Motion?

   • 1st Law: The Law of Inertia. An object at rest will stay at rest, and an object in motion will stay in motion (unless acted upon by an outside force).
   • 2nd Law: Force equals mass times acceleration. F = m*a
   • 3rd Law: For every action, there is an equal and opposite reaction. Think if you push against a wall, you feel it pushing back on you as well.

2. What is inertia?

   • The ability of an object to resist changes in its motion.
   • From Newton's second law, we see that this is an object's mass. More massive objects are harder to start accelerating from rest, and harder to stop moving once they get going. I can easily stop a ping pong ball rolling across a table, but not a boulder down a mountainside!

3. What formula did Newton write down for the strength of the force of gravity?

   • $F_G = \frac{Gm_1m_2}{r^2}$
   • This means that gravity scales with mass, and is inversely proportional to the distance between objects. A nearby object feels much more gravity than a distant one of the same mass.

4. If I drop a bowling ball and a pencil, which will hit the ground first? Why?

   • They will hit at the same time.
   • If we set the gravitational force equal to Newton?s second law, we can solve for the acceleration due to gravity.
   • $\frac{Gm_1m_2}{r^2} = \mathrm{m_1a}$
   • $\mathrm{a} = \frac{Gm_2}{r^2}$
   • You'll notice that the m_1 term divided out! So every object falls at the same rate, about $9.8m/s^2$ here on Earth.