AST 105 HW #2 Solution

Week of August 31st, 2015

Note: All Problems are from The Cosmic Perspective (6ed)

Chapter 3

Review Problems

1. In what way is scientific thinking natural to all of us? How does modern science differ from this everyday type of thinking?

Answer:

We all use the trial-and-error methods used in science frequently in our lives. Science builds upon this type of thinking by being more systematic in its approach, thereby facilitating discovery and collaboration.

2. Why did ancient peoples study astronomy? Describe astronomical achievements of at least three ancient cultures.

Answer:

Ancient cultures studied astronomy to track the changes of the seasons. They needed this information to help them plant, grow, and harvest crops each year

Egyptians-Used Sun and stars to tell time, giving us our 12-hour day and 12-hour night. Anasazi-Created the Sun Dagger, which marks the solstices and equinoxes with special illuminations on those days. Understood lunar cycles. Babylonians-Were able to predict eclipses accurately. Chinese-Kept detailed records of the skies for thousands of years. Polynesians-Experts at navigation, including celestial navigation.

3. How are the names of the 7 days of the week related to astronomical objects?

Answer:

Seven days of the week were named after the Sun, the Moon, and the five visible planets.

4. Describe at least three ways ancient peoples determined either the time of day or the time of year.

Answer:

The Egyptians determine the time of day by observing the shadows created by obelists. Stonehenge was constructed in a way that the sun would rise directly above the stone on the summer solstice. Few other important events are also marked on Stonehenge. The Temple Mayor was used to mark the seasons.

7. Summarize the development of the Greek geocentric model.

Answer:

The Greek geocentric model goes back a long way into the past. Early developments include the idea of the celestial sphere (5th century B.C., due to Anaximander), discovery that Earth is round (Eratosthenes was able to actually measure its radius around 240 B.C.), and the notion (due to Plato) that all of the celestial objects traveled in perfect circles. Eudoxus added separate spheres for each planet, as well as for the Sun and the Moon. Ptolemy incorporated all of this, as well as other ideas, into his Ptolemaic model, published in
the 2nd century A.D. His model was able to explain retrograde motion by having the planets move on smaller circles attached to the larger circles on which they went around Earth.

10. Why wasn’t the Copernican model immediately accepted? Describe the roles of Tycho, Kepler, and Galileo in the eventual triumph of the Sun-centered model.

Answer:

Copernicus assumed that planets orbits in perfect circular orbit. This assumptions forced him to introduce complications to his model. As a result, Copernican model was neither simpler nor more accurate than Ptolemy’s geocentric model.

Eventually, however, the heliocentric model prevailed. Tycho provided observational data. Using Tycho’s data, Kepler developed his three laws. The first of Kepler’s law states that planets have elliptical orbits with one of its focal points at the Sun. This departure from the perfect circular orbit vastly simplified the problem. Galileo built a telescope and empirically invalidated the geocentric model.

12. State each of Kepler’s laws of planetary motion. Describe the meaning of each law in a way that anyone could understand.

Answer:

Kepler’s first law: The orbit of each planet around the Sun is an ellipse with the Sun at one focus. This describes the shape of the orbits (ellipses rather than the circles used by most previous models) and where the Sun is located relative to the orbits (at a focus rather than in the center).

Kepler’s second law: As a planet moves around its orbit, it sweeps out equal areas in equal times. In other words, a line from a planet to the Sun sweeps out equal areas in equal amounts of time. This law describes how fast the planets move in their orbits. When they are close to the Sun, they move faster and when they are far away they move slower.

Kepler’s third law: More distant planets orbit the Sun at slower average speeds, obeying the mathematical relationship \( p^2 = a^3 \), where \( p \) is the planet’s orbital period (in years) and \( a \) is its semimajor axis (in AU). This law says that the more distant planets orbit more slowly than the ones that are closer to the Sun. It also says that the only thing that affects the orbital period of the planets is the semimajor axis. So things like the mass of the planet and the orbital eccentricity do not matter.

14. What is the difference between a hypothesis and a theory in science?

Answer:

A hypothesis is an educated guess. A hypothesis that has survived repeated tests and makes meaningful physical predictions can be elevated to a theory.

Test Your Understanding

Each of the following statements makes some type of claim. Decide in each case whether the claim could be evaluated scientifically or whether it falls into the realm of non-science. Explain clearly; not all of these have definitive answers, so your explanation is more important than your chosen answer.

ANSWERS TO PROBLEM 17 TO 26. If you can provide empirically ways to test a statement, it is scientific problem otherwise it is not. There is no clear answer here.

17. The Yankees are the best baseball team of all time.
18. Several kilometers below its surface, Jupiter’s moon Europa has an ocean of liquid water.

19. My house is haunted by ghosts who make the creaking noises I hear each night.

20. There is no liquid water on the surface of Mars today.

21. Dogs are smarter than cats.

12. Children born when Jupiter is in the constellation Taurus are more likely to be musicians than other children.

23. Aliens can manipulate time so that they can abduct and perform experiments on people who never realize they were taken.

24. Newton’s law of gravity works as well for explaining the orbits of planets around other stars as it does for explaining the orbits of planets in our own solar system.

25. God created the laws of motion that were discovered by Newton.


Quick Quiz
Choose the best answer to each of the following. Explain your reasoning with one or more complete sentences.

34. Which of the following is not true about scientific progress? (a) Science progresses through the creation and testing of models of nature. (b) Science advances only through the scientific method. (c) Science avoids explanations that invoke the supernatural.

Answers (b)
Some scientific progress happens accidently. A notable example is the discovery of penicillin by Alexander Fleming.

35. Which of the following is not true about a scientific theory? (a) A theory must explain a wide range of observations or experiments. (b) Even the strongest theories can never be proved true beyond all doubt. (c) A theory is essentially an educated guess.

Answers: (c)
An educated guess is called a hypothesis, not a theory. A theory must make testable predictions, and have survived a wide range of tests.

Chapter 4
Review Problems

6. What are the laws of conservation of momentum, conservation of angular momentum, and conservation of energy? For each, give an example of how it is important in astronomy.

Answer:
The conservation laws say that momentum, angular momentum, and energy are all conserved. That is, in a particular system, the total amount of each of these quantities does not change.

An example of conservation of momentum in astronomy is a rocket. If we start with a rocket at rest and fire the engines, the rocket expels a lot of hot gas out the back. To conserve momentum, the rocket must move forward.

Conservation of angular momentum is what gives us Kepler's second law: When a planet gets closer to the Sun, it has to move faster to keep its angular momentum the same as when it is farther from the Sun, when it moves slower.

Conservation of energy tells us that as an object falls to Earth's surface, it loses gravitational potential energy. To conserve energy, the object has to move faster as it falls. Eventually, it hits the ground and stops. At this point, its kinetic energy is converted to heat and sound.

7. Define kinetic energy, radiative energy, and potential energy. For each type of energy, give at least two examples of objects that either have it or use it.

Answer:

Kinetic energy is the energy an object has due to its motion. Two examples are a car driving down the highway or the movements of the molecules of liquid in a cup of hot coffee.

Potential energy is energy that is stored. It could be, for example, chemical, mechanical (e.g., by springs), gravitational, or nuclear. Two examples of potential energy are breakfast cereal, which has chemical potential energy, and a heavy book on the top shelf at the library, which has gravitational potential energy.

Radiative energy is energy in light. Sunlight carries this form of energy, as do other forms of light including X-rays and radio waves.

Test Your Understanding

Decide whether the statement makes sense (or is clearly true) or does not make sense (or is clearly false). Explain clearly; not all of these have definitive answers, so your explanation is more important than your chosen answer.

20. Suppose you could enter a vacuum chamber (on Earth), that is, a chamber with no air in it. Inside this chamber, if you dropped a hammer and a feather from the same height at the same time, both would hit the bottom at the same time.

Answer:

This statement is true. Without air resistance, all objects will fall under gravity at the same rate.

22. I used Newton’s version of Kepler’s third law to calculate Saturn’s mass from orbital characteristics of its moon Titan.

Answer:

This statement makes sense, because we can calculate the mass of Saturn by knowing the period and average distance for Titan.

23. If the Sun were magically replaced with a giant rock that had precisely the same mass, Earth’s orbit would not change.

Answer:

This statement is true, because the rock would have the same gravitational effect on Earth as does the Sun.
25. Venus has no oceans, so it could not have tides even if it had a moon (which it doesn’t).

Answer

This statement does not make sense, because tides affect an entire planet, not just the oceans. Thus, if Venus had a moon, it could have "land tides."

Quick Quiz

Choose the best answer to each of the following. Explain your reasoning with one or more complete sentences.

29. Which one of the following describes an object that is accelerating? (a) a car traveling on a straight, flat road at 50 miles per hour (b) a car traveling on a straight uphill road at 30 miles per hour (c) a car going around a circular track at a steady 100 miles per hour.

Answer

(c) If an object change its direction, then it is accelerating.

30. Suppose you visited another planet: (a) Your mass and weight would be the same as they are on Earth. (b) Your mass would be the same as on Earth, but your weight would be different. (c) Your weight would be the same as on Earth, but your mass would be different.

Answer

(b) Mass is conserved, but weight depends on the strength of gravitational field which varies from planet to planet.

37. According to the law of universal gravitation, what would happen to Earth if the Sun were somehow replaced by a black hole of the same mass? (a) Earth would be quickly sucked into the black hole. (b) Earth would slowly spiral into the black hole. (c) Earth’s orbit would not change.

Answer:

(b) The magnitude of the gravitational force on the Earth did not change. So the Earth's orbit would not change.