1. Which of the following planets is 11 times the size of the Earth?
   a. Venus  
   b. Uranus  
   c. Mars  
   d. Jupiter  
   e. Neptune

2. The photosphere of a protostar
   a. is the outer boundary of the collapsing cloud.  
   b. is where the pressure drops to zero. 
   c. is where the temperature is a maximum. 
   d. does not exist since only stars have photospheres. 
   e. is where light is last scattered.

3. Planets that are in orbit around stars other than our own Sun are most often found by observing
   a. small changes in starlight due to planetary transits. 
   b. telescope images of the planets. 
   c. the microlensing of light from background stars. 
   d. small wobbles in our own Sun.

4. Once a space probe has gotten far enough from the Earth, it can reach the inner planets by
   a. pointing itself toward those planets.  
   b. using its rocket motor and the gravity of various planets to change its speed and direction.  
   c. discarding spent rocket stages so that it slows down. 
   d. turning off its rocket motor and falling in toward the Sun.

5. On a world with liquid water but no life, carbon dioxide in the atmosphere would
   a. be stable because dissolved carbon dioxide comes out of solution whenever the carbon dioxide pressure drops. 
   b. increase as the water releases it from surface rocks. 
   c. decrease as the water dissolves it to form an acid that combines with surface rocks. 

6. Kepler’s First Law of Planetary Motion is that the orbit of each planet is
   a. a circle with the Sun at the center. 
   b. a circle with the Sun offset from the center. 
   c. an ellipse with the Sun at one focus. 
   d. an ellipse with the Sun at the center.

7. If we wish to find life with a carbon-return process similar to the one here on Earth, we should look for planets
   a. with volcanos.  
   b. with thick, stable surfaces.  
   c. larger than Mars.
8 Compared to a sidereal month, the time from one full Moon to the next is
   a. longer by four minutes.
   b. shorter by 2.5 days.
   c. longer by 2.5 days.
   d. exactly the same.
   e. shorter by four minutes.

9 The period of a proto-star’s evolution when its size and brightness decrease just before the ignition of nuclear
   reactions in its core is called
   a. the photosphere phase.
   b. the Tau Ceti phase.
   c. the Tau Tauri phase.
   d. the pre-ignition phase.

10 The wavelength of a wave is defined to be
   a. the number of waves passing in one second.
   b. the distance from one crest to the next.
   c. the maximum value of the quantity that is waving.
   d. the distance from a crest to a trough.
   e. the distance from one side of the wave to the other.

11 Far from the Sun, a comet is basically a
   a. lump of iron or rock.
   b. cloud of individual dust particles.
   c. ball of ionized gas.
   d. dirty lump of frozen gas and ice.

12 Which of the following planets or moons has an atmosphere whose temperature and pressure permit all three
   forms of water?
   a. Mars
   b. Venus
   c. Mercury
   d. Earth
   e. Titan

13 How many of the moons of Saturn are larger than the Earth’s Moon?
   a. 2
   b. 3
   c. 1
   d. 4
   e. 0

14 Saturn is about
   a. five times as far from the Sun as Jupiter.
   b. 50% farther from the Sun than Jupiter.
   c. twice as far from the Sun as Jupiter
   d. half as far from the Sun as Jupiter.
   e. the same distance from the Sun as Jupiter
15 The reason that the Crab Pulsar is slowing down is
   a. that it is getting older.
   b. that it is losing electric charge.
   c. that it is running out of nuclear fuel.
   d. tidal friction due to the gravity of a nearby star.
   e. its magnetic field is dragging through nearby gas.

16 The first generally accepted example of Sea-floor spreading was under the
   a. Indian Ocean.
   b. Atlantic Ocean.
   c. Pacific Ocean.
   d. English Channel.
   e. Gulf of Mexico.

17 The idea of a scientific fact presents difficulties for the falsificationist philosophy that we have been discussing because that philosophy insists that every scientific statement is
   a. infallible.
   b. subject to change.
   c. just a guess.

18 One reason that the Copernican System failed to fit Tycho’s observations was that
   a. it used circular orbits instead of ellipses.
   b. it used elliptical orbits instead of circles.
   c. it placed the Sun at the center of the system.
   d. it placed the Earth at the center of the universe.

19 The star Kruger 60 shows a heliocentric stellar parallax of almost exactly 0.25 seconds of arc. The distance from our Sun to Kruger 60 is
   a. 0.25 parsecs.
   b. 0.75 parsecs.
   c. 2 parsecs.
   d. 8 parsecs.
   e. 4 parsecs.

20 Pathfinder was the first
   a. to use airbags to land on Mars.
   b. Mars orbiter.
   c. Mars lander.
   d. to use ion drive rockets for planetary exploration.

21 The patent for inventing the telescope was obtained by
   a. Galileo.
   b. someone in the Netherlands.
   c. nobody because it was too simple an idea to patent.
   d. Newton.
22 The formation of electron-degenerate matter in the carbon core of a solar-mass red super giant
   a. triggers a flash of carbon-burning.
   b. leads to further core collapse.
   c. prevents carbon-burning from starting.
   d. causes the core to explode.
   e. returns the star to the horizontal branch.

23 The mass of a carbon atom is 12.00amu while the mass of a deuterium atom is 2.014amu. If a gamma ray photon
   splits a carbon atom into six deuterium atoms, how much energy is converted into mass?
   a. 0.014amu
   b. 0.056amu
   c. 0.009amu
   d. 0.084amu
   e. 0.168amu

24 Which of the following magnitudes corresponds to the brightest star?
   a. +3
   b. +2
   c. 0
   d. +4
   e. +1

25 Here is the Drake Equation: \[ N = R^* \times f_p \times n_e \times f_i \times f_l \times f_c \times L \]
   In this equation, \( n_e \) stands for the
   a. number of extraterrestrial messages that we might expect to detect in a year.
   b. average number of habitable planets in a planetary system.
   c. average number of new stars that form in a year.
   d. expected lifetime of a communication-capable civilization.
   e. number of communication-capable civilizations in our galaxy.

26 Earth’s orbit is currently elliptical enough to make the intensity of sunlight vary by 6 percent. The largest
   Earth-Sun distance (and lowest intensity sunlight) occurs
   a. every July.
   b. every Summer Solstice.
   c. at different times each year.
   d. every January.
   e. every Winter Solstice.

27 Which of the following particles has the smallest mass?
   a. neutron.
   b. positron.
   c. neutrino.
   d. deuteron.
   e. proton.
28. The absorption and re-radiation of infrared light by gases such as carbon dioxide is the key process in the
   b. creation of the ionosphere.
   c. destruction of the ozone layer.
   d. Stark Effect.
   e. creation of smog.

29. Which of the following objects has no overall magnetic field except for small regions due to magnetized ore deposits?
   a. Earth’s Moon
   b. Jupiter
   c. Mercury
   d. Mars
   e. Saturn

30. Civilizations capable of sending out broadcast messages that we could possibly detect across interstellar distances would have to be technologically advanced and would probably be much more advanced than we are. That makes it difficult to decide what sort of signals they would send. The SETI program has decided to listen for microwave signals rather than more exotic types of signals (such as laser light, gamma rays, neutrinos, gravitational waves, etc.). The main reason for this choice is that
   a. microwave technology will always be easier to use than more exotic communication technologies, even for unknown advanced civilizations.
   b. a microwave signal can be beamed directly at us, greatly increasing the signal strength that we receive.
   c. a microwave signal can send the largest amount of information for a given amount of energy used to generate the signal.
   d. a microwave signal is easier to receive by less advanced civilizations and thus would have a wider potential audience.

31. Pioneer 10 was an early space probe sent to fly past
   a. Venus
   b. Mercury
   c. Jupiter
   d. Mars
   e. Earth’s Moon

32. Had Jupiter ignited, we would be living in a multiple star system. Such systems
   a. have never been seen.
   b. are quite common.
   c. are almost universal.
   d. are extremely rare.

33. Of the following methods for eliminating an asteroid threat, which one would be affected least by the unknown composition and condition of the asteroid?
   a. Deflect or shatter the asteroid by crashing a missile into it.
   b. Deflect or shatter the asteroid with a nuclear explosion.
   c. Land on the asteroid and attach a rocket to it.
   d. Use the gravitational attraction of a massive spacecraft to pull the asteroid off course.
34. In the Hertzsprung-Russell Diagram shown, which point represents a star of type K with absolute magnitude +10?

35. Suppose that the color and behavior of a star identify it as a type that we know has absolute magnitude -3. If the star’s apparent magnitude is found to be 7, how far away is it?
   a. 10 parsecs.
   b. 100 parsecs.
   c. 50 parsecs.
   d. 1000 parsecs.
   e. 5 parsecs.

36. A star that is named Epsilon Eridani is most likely
   a. a fairly dim star in the constellation Eridanus.
   b. the brightest star in the constellation Cepheus.
   c. a fairly dim star in the constellation Cepheus.
   d. the brightest star in the constellation Eridanus.

37. The density of water is 1000 kg/m$^3$ while the density of rock is 3000 kg/m$^3$. Which of the following values is a plausible value for the density of a Jovian planet?
   a. 700 kg/m$^3$
   b. 10,000 kg/m$^3$
   c. 3000 kg/m$^3$
   d. 5000 kg/m$^3$

38. Suppose that the Space Shuttle is in a roughly circular orbit near the surface of the Earth, moving at around 5 miles per second. Suppose the Space Shuttle flips over backwards and fires its rocket engine to slow its speed to 4.96 miles per second. The shuttle will then
   a. follow an ellipse that descends a bit and then rises again.
   b. coast down to a slightly lower circular orbit.
   c. escape from the Earth.
   d. follow an ellipse that rises a bit and then descends again.

39. Mercury rotates so that its sidereal day lasts for
   a. one complete orbit around the Sun.
   b. two thirds of a complete orbit around the Sun.
   c. one and a half complete orbits around the Sun.
   d. three complete orbits around the Sun.
   e. two complete orbits around the Sun.
40 When the core of a star collapses while inside the star, the result is a
   a. type Ia supernova.
   b. ordinary nova.
   c. type II supernova.
   d. gamma-ray burst.

41 The first observed source to fit the predicted emissions from a black hole was
   a. Scorpius X-1.
   c. Cygnus X-1.
   d. Eridanus X-3.
   e. Taurus N6.

42 The asteroid 2007 VK184 has one chance in 2940 of hitting the Earth between the years 2048 and 2057. The asteroid is 130 meters in diameter or about half the size of Apophis. Assuming that an impact could cause the death of 1,000,000 people the average death rate for this type of event is closest to
   a. 100 people per event.
   b. 250 people per event.
   c. 10 people per event.
   d. 350 people per event.

43 The Moon rotates on its axis so that it always keeps
   a. the same side (its dark side) pointed away from the Sun.
   b. the same side (its far side) pointed away from the Earth.
   c. the same side toward a particular distant star.

44 A book, weighing 10 Newtons, sits on a table. Which of the following pairs of forces is an action-reaction pair?
   a. The force of gravity on the book and the force that the book exerts on the table.
   b. The force of gravity on the book and the force of gravity on the table.
   c. The force that the book exerts on the table and the force of gravity on the table.
   d. The force that the book exerts on the table and the force that the table exerts on the book.
   e. The force of gravity on the book and the force that the table exerts on the book.

45 In one day, the position of the Sun on the Celestial Sphere
   a. moves westward along the ecliptic by 1º.
   b. does not change at all.
   c. moves eastward along the ecliptic by 1º.
   d. moves westward along the ecliptic by 15º.
   e. Moves eastward along the ecliptic by 15º.

46 The Population II stars of our Milky Way
   a. orbit the central bulge only within the disk.
   b. orbit the central bulge in all directions.
   c. are mostly in the central bulge.
47 Icy objects were ejected outward from the neighborhood of the Jovian planets to form
   a. the Oort Cloud.
   b. the Moons of the Jovian planets.
   c. the oceans and atmosphere of Earth.
   d. the asteroid belt.
   e. the Kuiper belt.

48 The Earth’s motion around the Sun causes
   a. nearby stars to shift steadily in the same direction.
   b. all stars to move away from a point in the constellation Hercules.
   c. all stars to jump randomly around.
   d. nearby stars to shift back and forth once a year.

49 Gerard Kuiper predicted that the region we now call the "Kuiper Belt" should be empty.
   a. He was correct, which is why the region was named after him.
   b. He was incorrect because he assumed a mass for Pluto that is now known to be too large.
   c. He was incorrect because he assumed a mass for Pluto that is now known to be too small.
   d. He was incorrect because his calculations were wrong.

50 The violet lines in the Hydrogen spectrum are normally seen with wavelengths 410nm and 434nm. In the light
   of a star that is moving toward us, we might expect to see those lines at wavelengths of
   a. 415nm and 439nm
   b. 400nm and 424nm
   c. 410nm and 434nm

51 Aristotle pointed out that assuming that gravity pulls everything toward a common center
   a. explains why the Earth is flat.
   b. implies that a spherical Earth would be unstable.
   c. explains why the Earth is spherical.
   d. is impossible since things far from that center would be pulled sideways.

52 Cepheid variable stars with the same luminosity usually
   a. have the same apparent magnitude.
   b. are at the same distance from us.
   c. have similar periods.
   d. belong to the same star cluster.

53 An RNA molecule consists of
   a. two long chains of nitrogenous bases connected by pairs of sugar phosphate molecules.
   b. one long chain of amino acids with sugar phosphate molecules attached to the side of it.
   c. one sugar phosphate chain with single nitrogenous bases attached to the side of it.
   d. two sugar phosphate chains connected by pairs of nitrogenous bases.
54 Suppose that you drop two objects from the same height at the same time. Both objects are heavy enough to be unaffected by air resistance and one object is twice as heavy. Who predicted that both objects would hit the ground at the same time?
   a. Nobody predicted that.
   b. Pythagoras.
   c. Aristotle.
   d. Galileo.

55 Voyager 2 is the only space probe so far to have visited
   a. Saturn
   b. Jupiter
   c. Uranus
   d. Venus
   e. Mercury

56 The problem of stars "twinkling" due to atmospheric turbulence
   a. can be corrected by using a more powerful eyepiece.
   b. can only be corrected by putting telescopes in space.
   c. cannot be corrected.
   d. can be corrected by using a guide star.
   e. can be corrected by going to larger telescope mirrors.

57 The first successful soft landing on the Moon was
   b. Luna 21 in 1976.
   c. Surveyor 1 in 1969.
   e. Luna 21 in 1973.

58 Just after sunset, you might find
   a. A waxing crescent Moon setting in the east.
   b. A waxing crescent Moon rising in the west.
   c. A waxing crescent Moon setting in the west.
   d. A waning crescent Moon setting in the north.
   e. A waxing crescent Moon rising in the east.

59 The Greek philosopher who guessed that the Earth is a sphere because that is the most elegant and simple shape was
   a. Aristarchus.
   b. Pythagoras.
   c. Aristotle.
   d. Eratosthenes.
   e. Plato.
60 The range of distances of a planet from its primary star that will permit the existence of liquid water on the planet’s surface is called the
   a. water hole.
   b. inner system.
   c. habitable zone.
   d. triple point.

61 When the light from a star is spread out into a rainbow of colors, the resulting picture is called
   a. a spectrum.
   b. a frequency diagram.
   c. an energy level diagram.
   d. a speculum.
   e. an absorption diagram.

62 The two Hydrogen atoms in a water molecule are both attached
   a. to the Oxygen atom, on exactly opposite sides of the Oxygen atom.
   b. to each other to form a pair that is then attached to the Oxygen atom.
   c. to the Oxygen atom, but offset so that the molecule looks bent.

63 Which of the following statements qualifies as a falsifiable working hypothesis of the sort that Karl Popper would favor?
   a. Life arises whenever and wherever the conditions are right for it.
   b. Life arose on Earth and exists only there.
   c. Life arose somewhere and spreads from planet to planet through space-born spores.

64 Aristarchus measured the angle between the Sun and the Moon when exactly half of the Moon was illuminated. If the Sun were actually just two or three times as far away as the Moon, he would have found that angle to be
   a. exactly 90 degrees.
   b. less than 90 degrees by an amount too small for him to measure.
   c. less than 90 degrees by an amount that was easy for him to measure.
   d. greater than 90 degrees.

65 The thickness of the Earth’s crust is about
   a. 10 miles.
   b. 100 miles.
   c. half the radius of the Earth.
   d. one fifth the radius of the Earth.

66 The motion of tectonic plates is driven by
   a. asteroid impacts.
   b. convection currents in the Earth’s mantle.
   c. convection currents in the Earth’s core.
   d. the Moon’s gravitational attraction.
   e. the Sun’s gravitational attraction.
67 The atmospheric pressure on the surface of Mars is
   a. essentially zero.
   b. 90 times the surface pressure of Earth’s atmosphere.
   c. about 1% the surface pressure of Earth’s atmosphere.
   d. about the same as the surface pressure of Earth’s atmosphere.

68 A descending convection current in the Earth’s mantle is expected to cause
   a. a mid-ocean ridge where tectonic plates are pulled together.
   b. a mid-ocean ridge where tectonic plates are spreading apart.
   c. a magnetic domain in the Earth’s core.
   d. a deep ocean trench where tectonic plates are pulled together.
   e. a deep ocean trench where tectonic plates are spreading apart.

69 The Outer Oort Cloud is
   a. distributed along the rotation axis of the solar system.
   b. distributed in all directions.
   c. a belt of objects mostly in the plane of the solar system.
   d. a doughnut-shaped region with objects above and below the plane of the solar system.

70 From the way that solar eclipses happen, the ancient Greeks concluded that
   a. the Sun is farther from the Earth and smaller than the Moon
   b. the Sun is closer to the Earth and larger than the Moon.
   c. the Sun is farther from the Earth and larger than the Moon.
   d. the Sun is closer to the Earth and smaller than the Moon.

71 The distance modulus of a star at a distance of 10 parsecs would be
   a. 10.
   b. 0.
   c. -5.
   d. 5.
   e. 15.

72 When an interstellar cloud fragment does not have enough mass to form a star powered by nuclear fusion, but gets hot enough to glow for a while, it is called
   a. a planet.
   b. a yellow dwarf.
   c. a brown dwarf.
   d. a class M object.
   e. a white dwarf.

73 What astronomers refer to as a "standard candle" is defined as a light source whose
   a. size is known.
   b. apparent magnitude is known.
   c. spectral type is known.
   d. distance is known.
   e. absolute magnitude is known.
74 Most of the ancient Greek astronomers believed that the Earth was fixed at the center of the universe. There was one, however, who thought that the Sun was fixed and a rotating Earth moved around the Sun. That was
a. Eristarchus of Syene.
b. Aristotle
c. Ptolemy.
d. Aristarchus of Samos.
e. Plato.

75 Cepheid variable stars with the same period
a. usually belong to the same star cluster.
b. have similar luminosities.
c. are at similar distances from us.
d. have similar apparent magnitudes.

76 When the temperature of a gas increases, its molecules
a. move faster.
b. move slower.
c. get smaller.
d. get larger.

77 The stars of the Milky Way are found
a. only near the ecliptic.
b. in all parts of the celestial sphere.
c. only near the celestial poles.
d. only near the celestial equator.
e. in a band of stars stretching across the sky.

78 The first red giant phase of a star is caused by
a. the exhaustion of helium at its core
b. the collapse of its core.
c. the exhaustion of hydrogen at its core.
d. the ignition of helium at its core.
e. the ignition of hydrogen at its core.

79 A lunar crater is best described as
a. any large flat area that is lower than the surrounding area.
b. a mountain in the center of a flat area.
c. a circular ring wall surrounding a flat area.
d. a large, deep hole in the Moon.

80 The main reason to suspect that Europa has a subsurface ocean of water is
a. low fluxes of epithermal neutrons.
b. landmarks that are not rotating with the rest of the moon.
c. geysers of water shooting out through cracks in the moon.
d. patterns of cracks in the ice on its surface.
81 A star is seen to move by 0.4 seconds of arc between March 1, 1999 and September 1, 1999 and then back to its starting point on March 1, 2000. What is the parallax angle for this star?
   a. 0.2 seconds of arc.
   b. 0.1 seconds of arc.
   c. 0.4 seconds of arc.
   d. 0.3 seconds of arc.
   e. 0.8 seconds of arc.

82 The reason the temperature rises as you go higher in the stratosphere is that the Sun’s
   a. visible light heats the land.
   b. high energy particles heat the upper part of the Ionosphere.
   c. ultraviolet light heats the Ozone Layer.

83 Suppose that a sound wave has a wavelength of 12 meters and a frequency of 1Hz. What is the speed of sound?
   a. 8.34 m/s
   b. 0.012 m/s
   c. 1200 m/s
   d. 100 m/s
   e. 12 m/s

84 One way to change the course of an asteroid is to place a ‘mass driver’ on it. The mass driver is really just a catapult that throws things (like rocks for example) away from the asteroid. The force that acts on the combined object (mass driver plus asteroid) is actually exerted by
   a. the inertia of the asteroid.
   b. the fabric of space-time.
   c. gravity.
   d. the rocks that the catapult throws.
   e. the catapult that throws the rocks.

85 The second most common element in the universe is
   a. water.
   b. carbon.
   c. helium.
   d. silicon.
   e. hydrogen.

86 In Astronomy, the term “Microlensing” refers to the
   a. blocking of light from a distant star by the solid surface of a nearer object such as a planet.
   b. bending of light from a distant star by the gravity of a nearer object such as a planet.
   c. bending of light from a distant star by the atmosphere of a nearer object such as a planet.
   d. making of really small telescopes.
   e. blocking of light from a distant star by the atmosphere of a nearer object such as a planet.
87 Which of the following systems is closest to the plan of most current Earth life-forms?
   a. One DNA molecule carries out all of the chemical processes needed to construct and operate a life-form.
   b. Lots of RNA molecules copy themselves and also act as enzymes which construct and operate a life-form.
   c. One RNA molecule is used to make the proteins and enzymes that carry out all of the chemical processes needed to construct and operate a life-form.
   d. One DNA molecule is used to make RNA molecules which, in turn make the proteins and enzymes that construct and operate a life-form.
   e. One RNA molecule carries out all of the chemical processes needed to construct and operate a life-form.

88 You are looking down on the Earth from a spacecraft hovering far above. After watching for a while, you notice that, from your perspective, it is rotating counterclockwise. The part of the Earth that is directly below you must be the Earth’s
   a. North Pole.
   b. Equator.
   c. South Pole.

89 When an arrow is fired from a bow, the arrow keeps moving after it leaves the bow because
   a. no force stops it.
   b. the force of its inertia pushes it.
   c. the displaced air pushes it from behind.
   d. the force of the bow keeps acting on it.
   e. it is pointed at the front and has fins at the back.

90 An example of a planet with no liquid water at all and a dense carbon dioxide atmosphere is
   a. Mars
   b. Mercury
   c. Venus
   d. Earth

91 Most plants here on Earth are green because the process of converting carbon dioxide and water into organic matter uses only
   a. red, blue, green, and violet light.
   b. green light.
   c. red, blue, and violet light.
   d. blue and violet light.
   e. red light.

92 Sarah reports that she saw a green star close to the star Betelgeuse. She really saw it and was quite surprised. The most likely outcome of her report is that:
   a. Other people look near Betelgeuse. They do not see the green star, and attack her report as a mistake or a fraud.
   b. Nobody bothers to check her observation and nobody believes her either.
   c. Other people look near Betelgeuse. They see the star and confirm her report. She becomes famous as the discoverer of the first green star.
   d. Nobody bothers to check her observation and she becomes famous as the discoverer of the first green star.
93 The average radius of the Earth’s orbit is
   a. 0.01 au.
   b. 2.0 au.
   c. 0.1 au.
   d. 1.0 au.
   e. 5 au.

94 Which of the following colors indicates the coldest star?
   a. orange.
   b. yellow.
   c. blue.
   d. red.
   e. peach.

95 Eratosthenes of Syene is generally credited with using the angle of the noon Sun at Alexandria and Syene to
determine the
   a. length of a solar year.
   b. size of the Earth.
   c. distance from the Earth to the Sun.
   d. size of the Sun.
   e. time of the summer solstice.

96 The observed magnetic field of Mercury is surprising because it was expected to have
   a. no magnetic field at all because it rotates so slowly.
   b. a magnetic field similar to Earth’s because it is a terrestrial planet.
   c. no magnetic field at all because its density indicates only a small iron core.
   d. a much larger magnetic field because of its huge iron core.

97 A star that is in the lower left corner of an HR diagram is most likely a
   a. red giant star.
   b. brown dwarf star.
   c. main sequence star.
   d. horizontal branch star.
   e. white dwarf star.

98 Adaptive optics is used to correct telescopes for
   a. atmospheric turbulence.
   b. spherical aberration.
   c. poor light collection ability.
   d. the diffraction limit.
   e. chromatic aberration.
99 At 8pm, you see that the pointer stars of the Big dipper and the star Polaris are arranged in a vertical line. at what time, give or take a minute or so, would you see them arranged at 45 degrees to the vertical?
   a. It will never happen.
   b. 11:00 p.m. the same day.
   c. 10:00 p.m. the same day.
   d. 2:00 am. the next day.
   e. 8:00 p.m. the next day.

100 Joseph Weber designed a series of devices to detect ripples in space-time, called gravitational waves. After several years of effort, Joe announced that he had detected gravitational waves. He built several versions of his devices and they all detected the waves. When other people tried to build similar devices, none of them detected anything at all. Joe’s evidence was ignored by the scientific community because
   a. Scientists would not believe there was a possible source for gravitational waves strong enough to register on Joe’s detectors.
   b. Joe’s observations were not reproduced by others.
   c. Joe’s observations were sloppily done and not convincing.
   d. Joe was an Electrical Engineer and did not belong to the physicist club.

101 The star π³-Orionis is 8 parsecs from our Sun. The light from π³-Orionis has been traveling for
   a. 0.4 years.
   b. 2.4 years.
   c. 26.4 years.
   d. 0.125 years.
   e. 8.0 years.

102 A large asteroid impact causes the extinction of whole species mainly by the effects of the
   a. smoke and dust: It blocks the sunlight.
   b. noise: It scares them to death.
   c. blast and shock wave: It blows them away.
   d. light and heat: It incinerates them.

103 An ion rocket engine produces 10 Newtons of thrust. What acceleration can it give to a space probe with a mass of 1000kg?
   a. 0.01 m/s².
   b. 0.1 m/s².
   c. 0.001 m/s².
   d. 1000 m/s².
   e. 1 m/s².

104 Which of the following objects has a magnetic field whose North and South poles are displaced from its rotation axis poles and also from the center of the planet?
   a. Venus
   b. Neptune
   c. Saturn
   d. Mercury
   e. Jupiter
105. What total force will cause an object with a mass of 1 kg to gain 10 meters per second every second?
   a. 10 Newtons.
   b. 5 Newtons.
   c. 1 Newton.
   d. 2.5 Newtons.
   e. 9.8 Newtons.

106. Mars’ orbit is currently
   a. elliptical enough to make the intensity of sunlight vary by 6 percent.
   b. elliptical enough to make the intensity of sunlight vary by 40 percent.
   c. exactly circular.
   d. slightly elliptical but not enough to affect the intensity of sunlight.

107. Galileo said that once an object is set in motion, it will keep moving at the same speed so long as
   a. no force is acting on it.
   b. it is rolling rather than sliding.
   c. a force is acting on it to keep it moving.
   d. it is following a straight path.

108. As Saturn rotates,
   a. its south magnetic pole follows a large circular path around its north geographic pole but its north magnetic pole hardly moves at all.
   b. both its magnetic poles follow large circular paths around its geographic poles just as they do on Earth.
   c. both its magnetic poles remain almost motionless at its geographic poles.
   d. its north magnetic pole follows a large circular path around its north geographic pole but its south magnetic pole hardly moves at all.

109. Which of the following spectral types corresponds to a star on the main sequence?
   a. O2Ia
   b. B4IV
   c. K2III
   d. A2Ib
   e. G2V

110. The acceleration of Earth’s Moon is
   a. toward the Earth.
   b. opposite to the direction of the Moon’s motion.
   c. in the direction of the Moon’s motion.
   d. between the direction of the Moon’s motion and the direction from the Moon to the Earth.
   e. away from the Earth.

111. Cruising far from the Sun, we notice that the Sun’s apparent brightness has dimmed to 10 watts per square meter. We know that the apparent brightness at a distance of 1 au is 1000 watts per square meter. How far from the Sun are we?
   a. 1000 au
   b. 10 au
   c. 100 au
   d. 1 au
112 In Kepler’s Laws of planetary motion the Earth moves around a Sun that is fixed in space. In Newton’s theory,
   a. the Sun and Earth move around a common center of mass.
   b. the Sun and Earth do not really move at all.
   c. the Sun moves around the unmoving Earth.
   d. the Earth also moves around the unmoving Sun.

113 The moon Ganymede is
   a. larger than the planet Earth.
   b. larger than the planet Mars but smaller than the planet Earth.
   c. larger than the planet Mercury but smaller than the planet Mars.
   d. larger than Earth’s Moon but smaller than the planet Mercury.
   e. smaller than Earth’s Moon.

114 In a Hertzsprung-Russell diagram, the hottest stars are found
   a. on the right side.
   b. at the bottom.
   c. at the top.
   d. on the left side.

115 A planet with a large system of moons would have to be a
   a. Kuiper Belt object.
   b. Jovian Planet.
   c. terrestrial planet.

116 The first Kuiper Belt Object to be discovered was
   a. Eris.
   b. Varuna.
   c. Pluto.
   d. Quaoar.
   e. Neptune.

117 Which of the following statements is falsifiable?
   a. The Minoans were not the best civilization on Crete.
   b. The Minoans were not the first civilization on Crete.
   c. The Minoans were the best civilization on Crete.
   d. The Minoans were the first civilization on Crete.
   e. The Minoans were a civilization on Crete.

118 The Summer Solstice is the time when
   a. the noon sun is lowest in the sky.
   b. the sun crosses the Celestial Equator.
   c. the noon sun is highest in the sky.

119 The astronomers of Copernicus’s time rejected his model of the Solar System mostly because
   a. they failed to understand it.
   b. it did not account for observations any better than the Ptolemaic System.
   c. the Ptolemaic System was supported by the Church.
The closest star to our sun is about four light years away. In the center of our galaxy, a typical distance between neighboring stars would be

a. 4000 light years.
b. 4 light years.
c. 0.004 light years.
d. 40 light years.
e. 0.04 light years.
Answer Key: Fall 2015 FXB

1 Choice d. (Jupiter)
2 Choice e. (is where light is last scattered.)
3 Choice a. (small changes in starlight due to planetary transits.)
4 Choice b. (using its rocket motor and the gravity of various planets to change its speed and direction.)
5 Choice c. (decrease as the water dissolves it to form an acid that combines with surface rocks.)
6 Choice c. (an ellipse with the Sun at one focus.)
7 Choice c. (larger than Mars.)
8 Choice c. (longer by 2.5 days.)
9 Choice c. (the Tau Tauri phase.)
10 Choice b. (the distance from one crest to the next.)
11 Choice d. (dirty lump of frozen gas and ice.)
12 Choice d. (Earth)
13 Choice c. (1)
14 Choice c. (twice as far from the Sun as Jupiter)
15 Choice e. (its magnetic field is dragging through nearby gas.)
16 Choice b. (Atlantic Ocean.)
17 Choice b. (subject to change.)
18 Choice a. (it used circular orbits instead of ellipses.)
19 Choice e. (4 parsecs.)
20 Choice a. (to use airbags to land on Mars.)
21 Choice c. (nobody because it was too simple an idea to patent.)
22 Choice c. (prevents carbon-burning from starting.)
23 Choice d. (0.084amu)
24 Choice c. (0.)
25 Choice b. (average number of habitable planets in a planetary system.)
26 Choice a. (every July.)
27 Choice c. (neutrino.)
28 Choice a. (Greenhouse Effect.)
29 Choice d. (Mars)
30 Choice c. (a microwave signal can send the largest amount of information for a given amount of energy used to generate the signal.)
31 Choice c. (Jupiter)
32 Choice b. (are quite common.)
33 Choice d. (Use the gravitational attraction of a massive spacecraft to pull the asteroid off course.)
34 Choice e. (E)
35 Choice d. (1000 parsecs.)
36 Choice a. (a fairly dim star in the constellation Eridanus.)
37 Choice a. (700kg/m³)
38 Choice a. (follow an ellipse that descends a bit and then rises again.)
39 Choice b. (two thirds of a complete orbit around the Sun.)
40 Choice c. (type II supernova.)
41 Choice c. (Cygnus X-1.)
42 Choice d. (350 people per event.)
43 Choice b. (the same side (its far side) pointed away from the Earth.)
44 Choice d. (The force that the book exerts on the table and the force that the table exerts on the book.)
45 Choice c. (moves eastward along the ecliptic by 1°.)
46 Choice b. (orbit the central bulge in all directions.)
47 Choice a. (the Oort Cloud.)
48 Choice d. (nearby stars to shift back and forth once a year.)
49 Choice b. (He was incorrect because he assumed a mass for Pluto that is now known to be too large.)
50 Choice b. (400nm and 424nm)
51 Choice c. (explains why the Earth is spherical.)
52 Choice c. (have similar periods.)
53 Choice c. (one sugar phosphate chain with single nitrogenous bases attached to the side of it.)
54 Choice d. (Galileo.)
55 Choice c. (Uranus)
56 Choice d. (can be corrected by using a guide star.)
57 Choice d. (Surveyor 1 in 1966.)
58 Choice c. (A waxing crescent Moon setting in the west.)
59 Choice b. (Pythagoras.)
60 Choice c. (habitable zone.)
61 Choice a. (a spectrum.)
62 Choice c. (to the Oxygen atom, but offset so that the molecule looks bent..)
63 Choice b. (Life arose on Earth and exists only there.)
64 Choice b. (less than 90 degrees by an amount too small for him to measure.)
65 Choice a. (10 miles.)
66 Choice b. (convection currents in the Earth’s mantle.)
67 Choice c. (about 1% the surface pressure of Earth’s atmosphere.)
68 Choice d. (a deep ocean trench where tectonic plates are pulled together.)
69 Choice b. (distributed in all directions.)
70 Choice c. (the Sun is farther from the Earth and larger than the Moon.)
71 Choice b. (0.)
72 Choice c. (a brown dwarf.)
73 Choice e. (absolute magnitude is known.)
74 Choice d. (Aristarchus of Samos.)
75 Choice b. (have similar luminosities.)
76 Choice a. (move faster.)
77 Choice e. (in a band of stars stretching across the sky.)
78 Choice c. (the exhaustion of hydrogen at its core.)
79 Choice c. (a circular ring wall surrounding a flat area.)
80 Choice d. (patterns of cracks in the ice on its surface.)
81 Choice a. (0.2 seconds of arc.)
82 Choice c. (ultraviolet light heats the Ozone Layer.)
83 Choice e. (12 m/s)
84 Choice d. (the rocks that the catapult throws.)
85 Choice c. (helium.)
86 Choice b. (bending of light from a distant star by the gravity of a nearer object such as a planet.)
87 Choice d. (One DNA molecule is used to make RNA molecules which, in turn make the proteins and enzymes that construct and operate a life-form.)
88 Choice a. (North Pole.)
89 Choice a. (no force stops it.)
90 Choice c. (Venus)
91 Choice c. (red, blue, and violet light.)
92 Choice c. (Other people look near Betelgeuse. They see the star and confirm her report. She becomes famous as the discoverer of the first green star.)
93 Choice d. (1.0 au.)
94 Choice d. (red.)
95 Choice b. (size of the Earth.)
96 Choice a. (no magnetic field at all because it rotates so slowly.)
97 Choice e. (white dwarf star.)
98 Choice a. (atmospheric turbulence.)
99 Choice b. (11:00 p.m. the same day.)
100 Choice b. (Joe’s observations were not reproduced by others.)
101 Choice c. (26.4 years.)
102 Choice a. (smoke and dust: It blocks the sunlight.)
103 Choice a. (0.01 m/s².)
104 Choice b. (Neptune)
105 Choice a. (10 Newtons.)
106 Choice b. (elliptical enough to make the intensity of sunlight vary by 40 percent.)
107 Choice a. (no force is acting on it.)
108 Choice c. (both its magnetic poles remain almost motionless at its geographic poles.)
109 Choice e. (G2V)
110 Choice a. (toward the Earth.)
111 Choice b. (10au)
112 Choice a. (the Sun and Earth move around a common center of mass.)
113 Choice c. (larger than the planet Mercury but smaller than the planet Mars.)
114 Choice d. (on the left side.)
115 Choice b. (Jovian Planet.)
116 Choice c. (Pluto.)
117 Choice d. (The Minoans were the first civilization on Crete.)
118 Choice c. (the noon sun is highest in the sky.)
119 Choice b. (it did not account for observations any better than the Ptolemaic System)
120 Choice e. (0.04 light years.)
Where to find these questions in the notes

1. Module 012.108 The Jovian Planets Jupiter Surface
2. Module 014.201 Formation of the Solar System The Protostar Stage
3. Module 019.413 The Search for Life Extrasolar Planets
4. Module 011.113-g01 The Terrestrial Planets Mercury Space Probes
5. Module 016.303 Earth’s Living Surface The Carbon Cycle
7. **Module 018.313-g01 Requirements for Life The Requirements for a Carbon Cycle (22%)**
8. Module 007.509 Science Model Building Phases of the Moon
9. Module 025.401-g01 Evolution onto the Main Sequence (047.31)
10. Module 021.101 Using the Doppler Shift Describing Waves
11. Module 013.102-g01 Comets and the Outer Solar System Comets in Detail
12. Module 011.302 The Terrestrial Planets Earth Surface
13. **Module 012.215-g01 The Jovian Planets Saturn Moons(17%)**
14. Module 012.203-g01 The Jovian Planets Saturn Surface
15. Module 028.105 Collapsed Objects, The Pulsar in the Crab Nebula 050.23
16. EModule 016.102 Earth’s Living Surface An Active Crust EC2
17. Module 006.401 Science Scientific Statements The Scientific Fact Problem
18. Module 005.402 The Sky: Power of Observation Kepler’s War with Mars
19. EModule 020.405 Stellar Parallax and Distance Parallax Angle and Distance QR2
20. Module 011.524 The Terrestrial Planets Mars Space Probes
21. Module 007.604-g01 Science Model Building Phases of Venus (42%)
22. **Module 026.402 The Quiet Deaths of Ordinary Stars, Game Over: Everybody leaves 048.42 (29%)**
23. Module 025.202-g01 Mass and Energy (042.22)
24. Module 022.201-g01 Stellar Magnitudes and Distance Luminosity, The Magnitude Scale
25. **Module 019.505-g01 The Search for Life SETI: Search for ExtraTerrestrial Intelligence (28%)**
26. **Module 011.304-g02 The Terrestrial Planets Earth Orbit and Rotation(28%)**
27. Module 025.103 The Building Blocks of Matter (042.13)
28. EModule 015.402 Earth’s Atmosphere and Interior Greenhouse Effect EC5
29. **Module 011.512 The Terrestrial Planets Mars Magnetic Field (28%)**
30. Module 019.502-g01 The Search for Life SETI: Search for ExtraTerrestrial Intelligence
31. Module 012.124 The Jovian Planets Jupiter Space Probes
32. Module 014.403 Formation of the Solar System Jupiter Loses the Race
33. Module 017.501 Earth Impacts Asteroid Defense
34. Module 024.102B-g01 The Hertzsprung-Russell Diagram, A dot for each star
35. Module 022.402-g01 Stellar Magnitudes and Distance Luminosity, Finding the distance (54%)
36. Module 003.209-g01 The Sky: Celestial Sphere Star Names
Module 010.301 Solar System Overview The Jovian Planets
Module 009.601-g01 Science Models of Gravity Artificial Satellites
Module 011.106-g01 The Terrestrial Planets Mercury Orbit and Rotation
Module 027.501 Supernova Explosions, Types: I Clean and II Dirty 049.61
Module 028.403 Collapsed Objects, Detecting Black Holes 051.23
EModule 017.405 Earth Impacts Hunting Killer Asteroids RA1
Module 011.409-g01 The Terrestrial Planets Moon Orbit and Rotation
Module 008.601 Science Models of Motion Action and Reaction
*Module 003.504 The Sky: Celestial Sphere. The Path of the Sun (39%)
Module 029.411 The Milky Way Galaxy, What is its Overall Shape? (053.34)
**Module 014.501 Formation of the Solar System The Fates of Dirty Snowballs(33%)
Module 020.302 Stellar Parallax and Distance What Causes Parallax?
Module 014.505-g01 Formation of the Solar System The Fates of Dirty Snowballs
Module 021.202-g01 Using the Doppler Shift The Doppler Shift
Module 002.202 The Sky: Spherical Earth. Self-consistency
**Module 029.202 The Milky Way Galaxy, How we Measure Distances Within It (052.32) (29%)
Module 018.501-g01 Requirements for Life Reproduction (47%)
Module 008.401-g01 Science Models of Motion The Universality of Free Fall
Module 012.318 The Jovian Planets Uranus Space Probes
Module 020.205 Stellar Parallax and Distance Telescopes
Module 011.421 The Terrestrial Planets Moon Space Probes
Module 007.504 Science Model Building Phases of the Moon
**Module 002.102 The Sky: Spherical Earth. Elegance.(32%)
Module 019.402 The Search for Life Extrasolar Planets
Module 018.115-g01 Requirements for Life Light
Module 018.302-g01 Requirements for Life The Requirements for a Carbon Cycle
Module 019.101-g01 The Search for Life The Motivation
*Module 007.304 Science Model Building the Sun (36%)
Module 015.501 Earth’s Atmosphere and Interior The Earth’s Interior
Module 016.103 Earth’s Living Surface An Active Crust
Module 011.501-g01 The Terrestrial Planets Mars Surface (42%)
*Module 016.106-g01 Earth’s Living Surface An Active Crust (35%)
*Module 013.303 Comets and the Outer Solar System The Origin of Comets (37%)
Module 007.201 Science Model Building Earth-Moon System
Module 022.302 Stellar Magnitudes and Distance Luminosity, Apparent and Absolute Magnitudes (50%)
Module 025.504 Stars of Extreme Mass (047.44)
Module 022.501 Stellar Magnitudes and Distance Luminosity, Preview of the Distance Ladder
Module 004.301 The Sky: Wandering Planets Aristarchus (40%)
Module 029.201 The Milky Way Galaxy, How we Measure Distances Within It (052.31)
Module 025.301-g01 Ignition (042.31)
Module 029.102 The Milky Way Galaxy, How We See it (052.12)
**Module 011.406-g01 The Terrestrial Planets Moon Surface Features (32%)
Module 019.305 The Search for Life The Jovian Moons
Module 020.402 Stellar Parallax and Distance Parallax Angle and Distance
Module 015.305-g01 Earth’s Atmosphere and Interior Temperature Layers
Module 021.110-g01 Using the Doppler Shift Describing Waves
*Module 008.603-g01 Science Models of Motion Action and Reaction (36%)
Module 018.201-g01 Requirements for Life The Chemical Basis of Life
Module 013.504 Comets and the Outer Solar System Beyond the Oort Cloud
EModule 018.506 Requirements for Life Reproduction EC3
Module 007.402 Science Model Building Time and Compass Heading
Module 008.503 Science Models of Motion Force and Mass
Module 016.502 Earth’s Living Surface Comparing Earth to Other Planets
Module 018.404-g01 Requirements for Life The Energy Sources of Life
Module 001.204 The Sky: As Certain as the Sunrise
Module 010.101-g01 Solar System Overview The Big Picture
Module 023.102 Star Colors and Classes, Colors and Temperatures
Module 002.401 The Sky: Spherical Earth. Circumference
*Module 011.107-g01 The Terrestrial Planets Mercury Magnetic Field (38%)
Module 026.408-g01 The Quiet Deaths of Ordinary Stars, Game Over: Everybody leaves 048.54
**Module 020.206 Stellar Parallax and Distance Telescopes (29%)
Module 003.305 The Sky: Celestial Sphere Star Motions (45%)
EModule 001.202 The Sky: As Certain as the Sunrise. Reproducible CT1
Module 020.407 Stellar Parallax and Distance Parallax Angle and Distance
EModule 017.303 Earth Impacts Large Object Impacts EC4
EModule 008.515-g01 Science Models of Motion Force and Mass a = F/m QR1
Module 012.408 The Jovian Planets Neptune Magnetic Field
Module 008.506 Science Models of Motion Force and Mass F=ma
Module 011.509 The Terrestrial Planets Mars Orbit and Rotation
Module 008.201-g01 Science Models of Motion The Law of Inertia
Module 012.213-g01 The Jovian Planets Saturn Magnetic Field
Module 024.403-g01 The Hertzsprung-Russell Diagram, Luminosity Class
Module 009.201-g01 Science Models of Gravity The Moon and the Apple
**Module 022.102-g01 Stellar Magnitudes and Distance Luminosity, Brightness and Distance (21%)**

**Module 009.501-g01 Science Models of Gravity Making New Predictions**

**Module 012.119-g01 The Jovian Planets Jupiter Moons**

**Module 024.204 The Hertzsprung-Russell Diagram, Interpreting the diagram QR3**

**Module 010.304 Solar System Overview The Jovian Planets**

**Module 010.603-g01 Solar System Overview The Kuiper Belt**

**EModule 006.102 Science Scientific Statements How to test a statement (?) CT2**

**Module 003.601 The Sky: Celestial Sphere. The Seasons**

**Module 004.604 The Sky: Wandering Planets Why Copernicus Lost**

**Module 029.502 The Milky Way Galaxy, The Monster in the Core (055.12) (38%)**