1 A large asteroid impact can affect the Earth’s climate primarily by
   a. poisoning the air with its fumes.
   b. blocking the sunlight with its smoke and dust.
   c. heating the air with the heat of impact.
   d. producing strong winds from its passage.

2 The word 'Parallax' in the term 'Spectroscopic Parallax' is used because that term refers to
   a. the use of stellar parallax.
   b. a method for finding distances to stars.
   c. the use of parallel lines on the HR diagram.
   d. a method for finding the masses of stars.

3 The first human landing on the Moon was Apollo 11 in

4 Heliocentric Stellar Parallax causes
   a. all stars to jump randomly around.
   b. nearby stars to shift back and forth once a year.
   c. all stars to move away from a point in the constellation Hercules.
   d. nearby stars to shift steadily in the same direction.

5 If we detect that the intensity of the light from a star is mostly constant but drops slightly to a new constant value for a while and then returns to its normal level and repeats this behavior at regular intervals, we can reasonably suspect that
   a. the star is vibrating.
   b. the star has a planet in orbit around it.
   c. the star has a large dark spot on it.
   d. a rogue planet is passing between us and the star.

6 Near-Earth asteroids of the sort that caused the Tunguska blast and the Barringer Meteor Crater are
   a. all likely to be located within the next few years.
   b. not likely to be located within the next few years.
   c. mostly known by now.
   d. of no interest because they will probably hit somebody else.

7 Which of the following time periods is closest to the time from a New Moon to the next Waxing Quarter Moon?
   a. 91.3 days.
   b. 22.5 days.
   c. 273.9 days
   d. 18 hours.
   e. 7.5 days.

8 The onset of Helium burning at the core of a star normally begins with
   a. a core collapse.
   b. a complete shutdown of all nuclear reactions.
   c. a quiet transition to helium burning
   d. blowing out the hydrogen burning shell.
   e. an explosion in the helium core.
9 The nucleus of a comet consists of
   a. a cloud of vaporizing gas and dust.
   b. mostly rock and iron.
   c. frozen gas, ice, and dust.
   d. atoms that have gained or lost electrons.
   e. freely falling individual dust particles.

10 The star epsilon-Eridani shows a heliocentric stellar parallax near 1/3 seconds of arc. The distance from our Sun to epsilon-Eridani is near
   a. 3 parsecs.
   b. 1/3 parsecs.
   c. 9 parsecs.
   d. 4 parsecs.
   e. 6 parsecs.

11 You see a waning quarter Moon high in the night sky. What time is it?
   a. 10:00am.
   b. Midnight.
   c. 6:00pm
   d. 8:00pm.
   e. 5:00am

12 Current computer models of planet formation suggest that the Alpha Centauri system
   a. could have planets within the habitable zones of both Alpha Centauri A and Alpha Centauri B.
   b. could have planets within the habitable zone of Alpha Centauri A but not Alpha Centauri B.
   c. probably does not have planets because of the shifting gravitational fields in that system.

13 In the Hertzsprung-Russell Diagram shown, which point represents a star of type B with absolute magnitude +10?

14 Which of these moons has patterns of cracks in the ice on its surface, indicating a subsurface ocean?
   a. Enceladus.
   b. Europa.
   c. Ganymede.
   d. Titan.
15 Which of the following planets or moons is about 90% as large as the planet Jupiter?
   a. Titan
   b. Uranus
   c. Neptune
   d. Pluto
   e. Saturn

16 Which of the following planets or moons has an atmosphere with about 90 times the surface pressure of Earth’s.
   a. Venus
   b. Titan
   c. Mars
   d. Mercury

17 A planet that is following Kepler’s Laws, accelerates
   a. away from the Sun.
   b. toward the Sun.
   c. between the direction of the planets motion and the direction from the planet to the Sun.
   d. opposite to the direction of the planets motion.
   e. in the direction of the planets motion.

18 The time that it takes for the Earth to rotate once relative to the distant stars is called a
   a. solar day.
   b. stellar standard day.
   c. sidereal day.
   d. galilean day.
   e. zodiacal day.

19 The Kuiper Belt was named after Gerard Kuiper, who said that
   a. no such belt ever formed because of the disruptive effects of Neptune’s gravity.
   b. the belt formed early in the history of the solar system and should still be there, stabilized by orbital resonances with Neptune.
   c. the belt formed early in the history of the solar system but should not still be there because Neptune would have cleared its neighborhood of smaller objects.
   d. the belt formed early in the history of the solar system but should not still be there because Pluto would have cleared its neighborhood of smaller objects.

20 Suppose that an asteroid, about 1 kilometer in diameter, shows a 1 in 100 probability of an Earth impact fifty years in the future. Assume that an impact will trigger climate changes that would kill one billion (1,000,000,000) people. Also assume that each of these deaths represents $100,000 in lost production. Using the cold economic logic that we discussed in class, how much money should be budgeted to deflect the asteroid?
   a. one hundred billion dollars ($100,000,000,000).
   b. one billion dollars ($1,000,000,000).
   c. one hundred trillion dollars ($100,000,000,000,000).
   d. one trillion dollars ($1,000,000,000,000).
21 The ancient Greeks concluded that the Sun is farther from the Earth than the Moon because
   a. the Moon’s shadow falls on the Earth during a lunar eclipse.
   b. the Sun’s angular size is smaller than the angular size of the Moon.
   c. the Moon’s shadow falls on the Earth during a solar eclipse.
   d. the Earth’s shadow falls on the Moon during a lunar eclipse.
   e. the Earth’s shadow falls on the Moon during a solar eclipse.

22 Europe and North America are
   a. on plates that are moving past each other.
   b. each on a different plate and moving away from each other.
   c. each on a different plate and moving toward each other.
   d. atop a single plate and moving in unison.

23 Pythagoras proposed that the Earth was round probably because he
   a. was politically opposed to the flat-Earth faction.
   b. felt that the gods favored a spherical shape over a flat one.
   c. had heard that constellations were visible in Egypt that could not be seen from Greece.
   d. thought that the sphere was the simplest and most elegant shape.

24 Although most records from that time were lost in the burning of the Great Library at Alexandria, most historians say that the first actual measurement of the Earth’s circumference was made in the 3rd century BCE by
   a. Aristarchus of Samos
   b. Selucus of Seleucia.
   c. Eratosthenes of Cyrene.
   d. Aristotle.
   e. Claudius Ptolemaeus.

25 The Inner Oort Cloud is located
   a. between the outer edge of the Kuiper Belt and the orbit of Pluto
   b. between the orbit of Neptune and the inner edge of the Kuiper Belt.
   c. beyond the Kuiper Belt.
   d. in the same general area as Pluto.

26 The star Vega is 25 parsecs from our Sun. The light from Vega has been traveling for about
   a. 7.5    b. 80    c. 25    d. 12.5    e. 0.04 years.
27. Einstein’s Theory of Gravity has passed every well-understood observational test for over 100 years. However, there are some observations, which are not well-understood. For example, the Pioneer space probe is showing tiny deviations from its predicted course as it leaves the neighborhood of our solar system. A new theory, called "Modified Newtonian Dynamics," actually does not do as well as Einstein’s Theory at predicting most things, but it does predict those tiny deviations and also accounts for several other, apparently unrelated, anomalous observations as well. From what we have said about the way scientists think, which of the following receptions would you expect this new theory to get?
   a. There is great interest because the new theory suggests that Einstein’s Theory might be wrong.
   b. There is great disinterest because the new theory does not account for as many observational tests as Einstein’s Theory does.
   c. There is great hostility because the new theory challenges the established theory.
   d. There is great disinterest because there is no need to replace a theory that has passed every well-understood observational test.

28. Which of the following types of radiation has the lowest frequency on this list?
   a. heat radiation.
   b. X-rays.
   c. red light.
   d. green light.
   e. infrared light.

29. Which of the following astronomers is regarded as an early example of government-supported Big Science.
   a. Copernicus.
   b. Eratosthenes of Cyrene.
   c. Aristarchus of Samos.
   d. Tycho Brahe.

30. The dark markings on the Full Moon that make up the face of the "Man in the Moon" are called Lunar
   a. maria.
   b. craters.
   c. planitia.
   d. terrae.
   e. valleys.

31. The original source of energy for life forms that live near a black smoker is
   a. always the Sun by means of dead plant and animal matter that falls from the surface of the ocean.
   b. often tube worms.
   c. often bacteria.
   d. often chemicals generated by the heat of the Earth’s interior.

32. An example of a planet which may occasionally have liquid water but retains an atmosphere of mostly carbon dioxide is
   a. Venus
   b. Earth
   c. Mars
   d. Mercury
33 The capture theory, in which the Moon forms as a separate object similar to Earth and is then captured by the Earth, would predict that
   a. the Moon’s orbit should be in the plane of the ecliptic.
   b. the Moon should have an iron core similar to Earth’s.
   c. the Moon should not have an iron core.
   d. the Moon’s orbit should be in the plane of Earth’s equator.

34 In the Earth’s atmosphere, the amount of carbon dioxide is
   a. about the same as the typical amount of water.
   b. much less than the typical amount of water.
   c. much more than the typical amount of water.

35 The portion of the Earth that is solid iron and nickel is the
   a. inner core.
   b. crust.
   c. mantle.
   d. mesosphere.
   e. outer core.

36 An astronomical unit is defined to be
   a. the average distance from the Earth to the Moon.
   b. the distance to a star that shows one arc-second of parallax shift.
   c. the average amount of time it takes the Earth to complete one orbit around the Sun.
   d. the distance that light travels in a year.
   e. the average distance from the Earth to the Sun.

37 Underneath a place where the sea floor is disappearing into a deep ocean trench, one expects there to be
   a. a magnetic domain in the Earth’s core.
   b. a descending convection current in the Earth’s mantle.
   c. a horizontal current in the Earth’s mantle.
   d. a bubble in the Earth’s mantle.
   e. a rising convection current in the Earth’s mantle.

38 A solar sail is a large sheet of light-reflecting plastic spread on an extremely low-mass framework and attached to a spacecraft. Sunlight exerts a force on the sail and moves the spacecraft. Suppose the spacecraft has a total mass of 100kg (including the sail) and sunlight exerts a total force of 2N on the sail. What will be the acceleration of the spacecraft?
   a. 0.02m/s².
   b. 100m/s².
   c. 2m/s².
   d. 50m/s².
   e. 0.2m/s².

39 Once a star has evolved onto the Main Sequence in the HR Diagram, it
   a. drifts slowly toward lower mass and brightness.
   b. moves both up and down the sequence.
   c. stays at the same point until it runs out of fuel.
   d. evolves up the sequence toward higher brightness.
40 Suppose that a flash of lightning from a cloud 5000 meters away is followed by a clap of thunder two seconds later. Assume that the light arrived in a negligible time and calculate the speed of the sound waves.

a. 1250m/s  
b. 2m/s  
c. 5000m/s  
d. 1000m/s  
e. 2500m/s

41 In a Hertzsprung-Russell diagram, Red Giant stars such as Betelgeuse are

a. at the lower left.  
b. at the upper right.  
c. at the upper left.  
d. at the lower right.

42 Large numbers of protostars can be seen by using

a. an X-ray telescope.  
b. a (visible light) optical telescope.  
c. an ultraviolet telescope.  
d. an infra-red telescope.

43 An atom of ordinary hydrogen consists of a proton and

a. a neutron.  
b. a positron.  
c. an electron.  
d. a negatron.  
e. a neutrino.

44 When the helium fuel runs out at the center of a low-mass star like our Sun,

a. returns to the main sequence.  
b. moves off of the horizontal branch.  
c. leaves the main sequence.  
d. moves on to the horizontal branch.  
e. collapses to a white dwarf star.

45 The role of the DNA molecule in current Earth life is to

a. provide the patterns for the enzymes that carry out the chemical processes of life.  
b. store and release energy as needed.  
c. use photons to split water into oxygen, electrons, and hydrogen ions.  
d. store and release oxygen as needed.  
e. carry out all of the chemical processes of life.

46 Suppose that the U.S. Naval Observatory published a table saying that the Moon rose at 6:45 pm on April 25, 2008. That statement is most likely

a. a proven mathematical theorem.  
b. an actual observation of the natural world.  
c. an unsupported opinion.  
d. the result of a calculation.
47 The molecules of both liquid water and ice are held together by
   a. transferring electrons between water molecules to make electrically charged ions.
   b. the attraction between the hydrogen atoms on one water molecule and the oppositely charged oxygen atom on another.
   c. sharing electrons between water molecules.
   d. weak electrical fluctuations in one water molecule and the opposite electrical fluctuations that it induces in another.

48 Temperatures on the surface of Mercury are
   a. similar to temperatures in Antarctica.
   b. extremely high everywhere because it is so close to the Sun.
   c. quite uniform because its thick atmosphere spreads the heat.
   d. extremely varied because it has no atmosphere to spread the heat.

49 As seen from North America, the constellation Cassiopeia
   a. sets in the west.
   b. sets in the south.
   c. sets in the north.
   d. sets in the east.
   e. never sets.

50 From the motions of nearby stars, the mass of the radio source Sgr A* is found to be spread
   a. over a region less than a few light days across.
   b. throughout the nearby stars.
   c. over a region a few light years across.

51 The density of water is 1000kg/m$^3$ while the density of iron is 7800kg/m$^3$. Which of the following values is a plausible value for the density of a terrestrial planet?
   a. 5000kg/m$^3$
   b. 500kg/m$^3$
   c. 1000kg/m$^3$
   d. 20,000kg/m$^3$
   e. 10,000kg/m$^3$

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

53 What total force will cause an object with a mass of 1kg to gain 5 meters per second every second?
   a. 5 Newtons.
   b. 10 Newtons.
   c. 9.8 Newtons.
   d. 1 Newton.
   e. 2.5 Newtons.
54 Galileo had no difficulty accounting for the motion of a thrown object because
   a. a force was needed to stop the object.
   b. no force was needed to keep the object moving.
   c. a force was needed to start the object moving.
   d. a force was needed to keep the object moving.
   e. no force was needed to start the object moving.

55 The key argument against the Moon forming from the Earth alone, by breakup of a single object is that the Moon’s
   a. core lacks iron.
   b. size is very large compared to Earth.
   c. orbit is tilted relative to Earth’s equator.
   d. orbit is tilted relative to the ecliptic.

56 As the two foci of an ellipse are moved apart, the shape of the ellipse becomes
   a. more like a line between the foci.
   b. more like a sphere around the foci.
   c. more like a circle around the foci.
   d. more like a triangle drawn around the foci.

57 Kepler’s Laws
   a. are explained by a force that attracts each planet to the Sun.
   b. are explained by the action of magnetic fields on each planet.
   c. are explained by a force that repels each planet from the Sun.
   d. are explained by a force in the direction of each planet’s motion.
   e. have never been explained.

58 The space shuttle is in a roughly circular orbit near the surface of the Earth, moving at around 5 miles per second. Suppose that it is desired to lower it to a new circular orbit, slightly closer to the surface. The shuttle flips over and fires its main rocket engine in a short burst to slow its speed to 4.96 miles per second. What must it do next?
   a. Boost its speed a bit when its distance from the Earth stops decreasing.
   b. Nothing. It will drop to a new, lower circular orbit.
   c. Slow its speed again by a bit when its distance from the Earth stops decreasing.
   d. Rethink its plan because decreasing its speed will put it into an orbit that is farther from the surface.

59 The time from one Full Moon to the next is 29.5 days. The length of a sidereal month is
   a. 29.3 days.
   b. 29.5 days.
   c. 32 days.
   d. 29.7 days.
   e. 27 days.

60 When the rocket engine in a spaceship stops firing, the spaceship keeps moving because
   a. the force of its inertia pushes it.
   b. it is pointed at the front and has fins at the back.
   c. no force stops it.
   d. the force exerted by the rocket engine earlier keeps acting on it.
61 Which of the following planets or moons has an atmosphere consisting mainly of Hydrogen and Helium with some methane?
   a. Venus
   b. Neptune
   c. Titan
   d. Saturn

62 Pioneer 11 was an early space probe sent to fly past
   a. Mercury
   b. Saturn
   c. Mars
   d. Earth’s Moon
   e. Venus

63 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 white dwarf.
   b. a brown dwarf.
   c. a yellow dwarf.
   d. a planet.
   e. a class M object.

64 Liquid water tends to remove carbon dioxide from the atmosphere of a planet by
   a. combining with it to form a solid precipitate.
   b. splitting it into carbon and oxygen.
   c. decomposing it into carbon and oxygen.
   d. dissolving it and washing it out of the atmosphere.

65 In SETI programs, the "water hole" refers to
   a. the range of signal frequencies that are not strongly absorbed or interfered with in our atmosphere and in interstellar space.
   b. the range of signal frequencies between emissions caused by hydrogen and hydroxyl molecules.
   c. a quiet spot in the radio band that is caused by interactions with water molecules in interstellar space.

66 The star Sirius can be located by using the pointer stars in
   a. Cassiopeia.
   b. Orion.
   c. The Big Dipper.
   d. Leo.
   e. The Little Dipper.

67 The time from one solar noon to the next is
   a. Slightly less than 24 hours.
   b. Exactly 24 hours.
   c. Slightly more than 24 hours.
68 The Greenhouse Effect is important because it suggests an effect on
   a. shielding UV light from the Sun.
   b. the Earth's rotation.
   c. near-Earth asteroids.
   d. the Earth's climate.
   e. the availability of greenhouses.

69 Which of the following types of radiation has the second lowest frequency on this list?
   a. infrared light.
   b. red light.
   c. heat radiation.
   d. green light.
   e. X-rays.

70 A star is observed to have an apparent brightness which is $10^{-6}$ times its absolute brightness. How far away is it?
   a. 1000 parsecs.
   b. 100 parsecs.
   c. 10,000 parsecs.
   d. $10^6$ parsecs.
   e. 10 parsecs.

71 Copernicus argued that the final version of the Ptolemaic System failed to satisfy a basic assumption of the original Ptolemaic System because it
   a. had the Earth moving around the Sun.
   b. had the Sun moving around the Earth.
   c. had the Earth fixed in place at the center of the universe.
   d. did not really have anything fixed in place at the center of the universe.

72 Suppose that a star has a spectrum that includes red, blue, and violet lines spaced in the pattern of the lines from hydrogen but the violet lines are at 424nm and 400nm instead of the usual 434nm and 410nm. From this evidence, you can conclude that the star is
   a. unusually hot.
   b. moving toward us.
   c. rotating.
   d. unusually cold.
   e. moving away from us.

73 The angle between the rotation axis of a planet and the perpendicular to the plane of its orbit is called its “axial tilt.” Which of these planets has an axial tilt that is less than one degree?
   a. Uranus.
   b. Mars.
   c. Mercury.
   d. Earth.
   e. Saturn.

74 Which of the following magnitudes corresponds to the brightest star?
   a. +3    b. +2    c. +1    d. 0    e. +4
75 The iron core of an evolved massive star collapses because
   a. the weight of the rest of the star goes away.
   b. its temperature rises faster when iron nuclei come apart.
   c. its temperature rise stops when iron nuclei come apart.
   d. the weight of the rest of the star increases.
   e. its temperature suddenly goes to zero.

76 The number of near-Earth asteroids that are more than one kilometer in diameter appears to be close to
   a. 10.
   b. 300,000
   c. 1000.
   d. 3,000,000
   e. 30,000

77 The core of a red supergiant star stops shrinking because its
   a. nuclei touch each other.
   b. electrons touch each other.
   c. pressure rises.
   d. temperature rises.

78 If you are looking down over the north pole of the Earth, you will see the Earth rotate
   a. counterclockwise.
   b. clockwise.
   c. downward.
   d. upward.

79 The sun usually sets in the
   a. North.
   b. East.
   c. Ocean.
   d. West.
   e. South.

80 Nuclei such as protons do not fuse at low temperatures because their speeds are not enough to overcome their
   a. structural integrity.
   b. hard shells.
   c. inertia.
   d. nuclear friction.
   e. electrical repulsion.

81 Sedna is thought to be
   a. in the Main Kuiper Belt.
   b. a Scattered Disk Object.
   c. in the asteroid belt.
   d. in the Inner Oort Cloud.
   e. in the Outer Oort Cloud.
82 Suppose that a sound wave has a wavelength of 12 meters and a frequency of 100Hz. What is the speed of sound?
   a. 8.34 m/s
   b. 100 m/s
   c. 12 m/s
   d. 1200 m/s
   e. 0.012 m/s

83 A DNA molecule consists of
   a. two sugar phosphate chains connected by single amino acids.
   b. two long chains of amino acids connected by pairs of sugar phosphate molecules.
   c. two long chains of nitrogenous bases connected by sugar phosphate molecules.
   d. two sugar phosphate chains connected by pairs of nitrogenous bases.

84 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.

85 The mass of a carbon atom is 12.00amu while the mass of a helium-4 atom is 4.003amu. If a gamma ray photon splits a carbon atom into three Helium atoms, how much energy is converted into mass?
   a. 0.006amu
   b. 0.009amu
   c. 0.012amu
   d. 0.002amu
   e. 0.004amu

86 In a particular binary star system, we are able to determine the masses of both stars in the system as well as the angle between our line of sight and the plane of the stars’ orbits but cannot determine the diameters or atmospheric compositions of the two stars. This system is most likely
   a. a visual binary system.
   b. a spectroscopic binary system.
   c. an eclipsing spectroscopic binary system.

87 Which of the following objects is the largest moon of Jupiter?
   a. Callisto
   b. Triton
   c. Titania
   d. Ganymede
   e. Titan

88 The most common element in the universe is
   a. hydrogen.
   b. carbon.
   c. water.
   d. silicon.
   e. helium.
89 According to our current model of how planets form magnetic fields, the magnetic field of Saturn is much less than the magnetic field of Jupiter because Saturn
   a. has less metallic hydrogen in its core than Jupiter.
   b. has less ammonia-water mixture in its core than Jupiter.
   c. rotates more rapidly than Jupiter.
   d. has less liquid iron in its core than Jupiter.
   e. rotates more slowly than Jupiter.

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

91 Viking 1 and 2 were sent to explore
   a. the planet Venus.
   b. the planet Mars.
   c. the planet Jupiter.
   d. the planet Neptune.
   e. Earth’s Moon.

92 Near the center of the Milky Way there is an intense radio source whose mass is approximately three
   a. thousand solar masses extending several light years from the center.
   b. thousand solar masses within several light days of the center.
   c. million solar masses extending several light years from the center.
   d. million solar masses within several light days of the center.

93 The first telescope was (possibly) built by
   a. Newton.
   b. Galileo.
   c. Tycho Brahe.
   d. Someone in the Netherlands.

94 The star Wemadeit shows a stellar parallax angle of 0.4 seconds of arc while the star Waytoofar shows a stellar parallax angle of 0.3 seconds of arc. From this, you can conclude that
   a. Waytoofar is closer to our Sun than Wemadeit.
   b. Both stars are at the same distance from our Sun.
   c. Waytoofar is moving faster than Wemadeit.
   d. Wemadeit is moving faster than Waytoofar.
   e. Wemadeit is closer to our Sun than Waytoofar.

95 The event horizon of a black hole is the point at which
   a. light rays are bent into circular orbits.
   b. all light rays escape from the hole.
   c. inwardly directed light rays escape from the hole.
   d. outwardly directed light rays are pulled into the hole.
96 Which of the following spacecraft is the only one to have flown past Uranus?
   a. Cassini-Huygens
   b. Voyager 1
   c. Pioneer 11
   d. Voyager 2
   e. Galileo

97 Which of these is a statement of the Fermi Paradox?
   a. We are never special.
   b. The strength of an interstellar signal falls off as the square of the distance but the expected number of such signals increases as the square of the distance, so where are they?
   c. Not only do you never get more than you pay for, you never break even.
   d. Because time in a moving reference frame is much slower than in the rest frame, aliens can get anywhere they want to in a very short amount of their own time, so where are they?
   e. Any long-lasting technological civilization should be obvious and might even be visiting us, so where are they?

98 A star that is hotter than most other stars will probably look
   a. blue.
   b. red.
   c. peach.
   d. orange.
   e. yellow.

99 On Earth, you might find a temperature of 59°F on a Spring or Fall day in the temperate zone. On Mars, you might expect that temperature
   a. nowhere on Mars.
   b. only at the poles.
   c. almost anywhere on Mars when the Sun is shining.
   d. at noon near the equator.

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. Joe’s observations were sloppily done and not convincing.
   b. Joe was an Electrical Engineer and did not belong to the physicist club.
   c. Scientists would not believe there was a possible source for gravitational waves strong enough to register on Joe’s detectors.
   d. Joe’s observations were not reproduced by others.

101 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. Aristotle.
   c. Galileo.
   d. Pythagoras.
102 A steady X-ray signal with sudden bursts lasting a few seconds each is probably caused by
   a. a supermassive star.
   b. a main sequence star.
   c. a white dwarf in a binary system.
   d. an isolated neutron star.
   e. a neutron star in a binary system.

103 Space probes often use gravitational slingshot maneuvers. The main purpose of these maneuvers is to
   a. arrive at the destination at the right time.
   b. change the direction and speed of the probe without using rockets.
   c. launch probes from Earth orbit without using rockets.
   d. see more planets in a single trip.

104 Retrograde Motion refers to
   a. planets appearing to move backwards relative to the distant stars in relation to their usual motion.
   b. planets appearing to rotate backwards on their axes relative their usual direction of rotation.
   c. planets actually moving backwards relative to the distant stars in relation to their usual motion.
   d. planets actually rotating backwards on their axes relative their usual direction of rotation.

105 A star with an absolute magnitude of $8.4$ and an apparent magnitude of $-1.0$ would appear in our sky as a star
   a. of average naked-eye brightness.
   b. barely visible to the naked eye.
   c. visible only with a telescope.
   d. of dazzling brightness.

106 The ancient Greeks were able to calculate the distance from the Earth to the Moon by using a geometrical model of
   a. an eclipse of the Sun.
   b. an eclipse of the Moon.
   c. the quarter phases of the Moon.

107 The rotation axis of Saturn is
   a. almost in the plane of its orbit so that its ring system can sometimes be seen as near-circles.
   b. inclined at an angle to the perpendicular that is similar to Earth’s rotation axis.
   c. nearly perpendicular to the plane of its orbit, so it has no seasons.

108 Which of the following planets is 11 times the size of the Earth?
   a. Mars
   b. Jupiter
   c. Venus
   d. Neptune
   e. Uranus
109 The Viking Landers carried out several experiments on Martian surface soil. One of those experiments, the Pyrolytic Release Experiment gave a positive result for the presence of life forms. That result was interpreted to mean
   a. nothing because a sterilized control sample gave the same result.
   b. nothing because it contradicted the results of the other experiments.
   c. that life might exist in Martian surface soil.

110 A star is found to have absolute magnitude 4 and apparent magnitude 24. How far away is it?
   a. 10,000 parsecs.
   b. 20 parsecs.
   c. 200 parsecs.
   d. 10 parsecs.
   e. 100,000 parsecs.

111 The largest dwarf planet in the Kuiper Belt is
   a. Pluto.
   b. Quaoar.
   c. Varuna.
   d. Sedna.
   e. Eris.

112 Which of the following planets has no magnetic field of any kind?
   a. Mars
   b. Saturn
   c. Venus
   d. Jupiter
   e. Mercury

113 The first indication that Cygnus X-1 might be a black hole was
   a. the rapid fluctuations in its X-rays.
   b. the intensity of its X-rays.
   c. the weakness of its X-rays.
   d. the steadiness of its X-ray signal.
   e. its detailed X-ray spectrum.

114 The magnetic field of Mars is
   a. about 100 times the intensity of the Earth’s magnetic field.
   b. about 10 times the intensity of the Earth’s magnetic field.
   c. essentially zero.
   d. similar in intensity to the Earth’s magnetic field.
   e. about 1% of the Earth’s magnetic field.

115 One model for the formation of the Solar System is that the planets formed from a cloud of material extracted from the Sun by a chance encounter with a passing star.
   a. This model incorrectly predicts planets orbiting in the plane of the Sun’s equator.
   b. This model correctly predicts planets orbiting out of the plane of the Sun’s equator.
   c. This model incorrectly predicts planets orbiting out of the plane of the Sun’s equator.
   d. This model correctly predicts planets orbiting in the plane of the Sun’s equator.
116 The recoil or ‘kick’ of a gun that is firing a bullet is a force exerted on the gun by
   a. the inertia of the gun.
   b. the air around the gun.
   c. the gun itself.
   d. the bullet.
   e. the hand of the shooter.

117 It is expected that a normal Jovian planet, with no accidental encounters that could add or subtract moons, should have
   a. no moon.
   b. just one moon.
   c. a family of moons, all orbiting in the plane of the planet's equator.

118 Think of the ‘front’ of a telescope as the end that light enters. A telescope with Cassegrain Focus has the eyepiece
   a. off to one side in a position that stays fixed when the telescope moves.
   b. at the back of the telescope.
   c. inside the telescope barrel.
   d. sticking out the side near the back.
   e. sticking out the side near the front.

119 What astronomers refer to as a "standard candle" is defined as a light source whose
   a. distance is known.
   b. apparent magnitude is known.
   c. spectral type is known.
   d. size is known.
   e. absolute magnitude is known.

120 Which of the following statements describes the relation between what we observe and the predictions of the nebular model of the formation of the Solar System?
   a. The model predicts rocky planets nearest to the Sun and we observe rocky planets there.
   b. The model predicts rocky planets throughout the Solar System and we observe rocky planets everywhere.
   c. The model predicts rocky planets throughout the Solar System and we observe rocky planets only far from the Sun.
   d. The model predicts rocky planets throughout the Solar System and we observe rocky planets only nearest to the Sun.
   e. The model predicts icy planets nearest to the Sun and we observe rocky planets there.
Answer Key: Spring 2018 FX-02

1 Choice b. (blocking the sunlight with its smoke and dust.)
2 Choice b. (a method for finding distances to stars.)
3 Choice d. (1969.)
4 Choice b. (nearby stars to shift back and forth once a year.)
5 Choice b. (the star has a planet in orbit around it.)
6 Choice b. (not likely to be located within the next few years.)
7 Choice e. (7.5 days.)
8 Choice e. (an explosion in the helium core.)
9 Choice c. (frozen gas, ice, and dust.)
10 Choice a. (3 parsecs.)
11 Choice e. (5:00am)
12 Choice a. (could have planets within the habitable zones of both Alpha Centauri A and Alpha Centauri B.)
13 Choice a. (A)
14 Choice b. (Europa.)
15 Choice e. (Saturn)
16 Choice a. (Venus)
17 Choice b. (toward the Sun.)
18 Choice c. (sidereal day.)
19 Choice d. (the belt formed early in the history of the solar system but should not still be there because Pluto would have cleared its neighborhood of smaller objects.)
20 Choice d. (one trillion dollars ($1,000,000,000,000).)
21 Choice c. (the Moon’s shadow falls on the Earth during a solar eclipse.)
22 Choice b. (each on a different plate and moving away from each other.)
23 Choice d. (thought that the sphere was the simplest and most elegant shape.)
24 Choice c. (Eratosthenes of Cyrene.)
25 Choice c. (beyond the Kuiper Belt.)
26 Choice b. (80 years.)
27 Choice d. (There is great disinterest because there is no need to replace a theory that has passed every well-understood observational test.)
28 Choice a. (heat radiation.)
29 Choice d. (Tycho Brahe.)
30 Choice a. (maria.)
31 Choice d. (often chemicals generated by the heat of the Earth’s interior.)
32 Choice c. (Mars)
33 Choice b. (the Moon should have an iron core similar to Earth’s.)
34 Choice b. (much less than the typical amount of water.)
35 Choice a. (inner core.)
36 Choice e. (the average distance from the Earth to the Sun.)
37 Choice b. (a descending convection current in the Earth’s mantle.)
38 Choice a. (0.02m/s²)
39 Choice c. (stays at the same point until it runs out of fuel.)
40 Choice e. (2500m/s)
41 Choice b. (at the upper right.)
42 Choice d. (an infra-red telescope.)
43 Choice c. (an electron.)
44 Choice b. (moves off of the horizontal branch.)
45 Choice a. (provide the patterns for the enzymes that carry out the chemical processes of life.)
46 Choice d. (the result of a calculation.)
47 Choice b. (the attraction between the hydrogen atoms on one water molecule and the oppositely charged oxygen atom on another.)
48 Choice d. (extremely varied because it has no atmosphere to spread the heat.)
49 Choice e. (never sets.)
50 Choice a. (over a region less than a few light days across.)
51 Choice a. (5000kg/m³)
52 Choice b. (in a band of stars stretching across the sky.)
53 Choice a. (5 Newtons.)
54 Choice b. (no force was needed to keep the object moving.)
55 Choice c. (orbit is tilted relative to Earth’s equator.)
56 Choice a. (more like a line between the foci.)
57 Choice a. (are explained by a force that attracts each planet to the Sun.)
58 Choice c. (Slow its speed again by a bit when its distance from the Earth stops decreasing.)
59 Choice e. (27 days.)
60 Choice c. (no force stops it.)
61 Choice b. (Neptune)
62 Choice b. (Saturn)
63 Choice b. (a brown dwarf.)
64 Choice d. (dissolving it and washing it out of the atmosphere.)
65 Choice b. (the range of signal frequencies between emissions caused by hydrogen and hydroxyl molecules.)
66 Choice b. (Orion.)
67 Choice b. (Exactly 24 hours.)
68 Choice d. (the Earth’s climate.)
69 Choice a. (infrared light.)
70 Choice c. (10,000 parsecs.)
71 Choice d. (did not really have anything fixed in place at the center of the universe.)
72 Choice b. (moving toward us.)
73 Choice c. (Mercury.)
74 Choice d. (0.)
75 Choice c. (its temperature rise stops when iron nuclei come apart.)
76 Choice c. (1000.)
77 Choice b. (electrons touch each other.)
78 Choice a. (counterclockwise.)
79 Choice d. (West.)
80 Choice e. (electrical repulsion.)
81 Choice d. (in the Inner Oort Cloud.)
82 Choice d. (1200 m/s)
83 Choice d. (two sugar phosphate chains connected by pairs of nitrogenous bases.)
84 Choice b. (have similar luminosities.)
85 Choice b. (0.009amu)
86 Choice a. (a visual binary system.)
87 Choice d. (Ganymede)
88 Choice a. (hydrogen.)
89 Choice a. (has less metallic hydrogen in its core than Jupiter.)
90 Choice c. (The Minoans were the first civilization on Crete.)
91 Choice b. (the planet Mars.)
92 Choice d. (million solar masses within several light days of the center.)
93 Choice d. (Someone in the Netherlands.)
94 Choice e. (Wemadeit is closer to our Sun than Waytoofar.)
95 Choice d. (outwardly directed light rays are pulled into the hole.)
96 Choice d. (Voyager 2)
97 Choice e. (Any long-lasting technological civilization should be obvious and might even be visiting us, so where are they?)
98 Choice a. (blue.)
99 Choice d. (at noon near the equator.)
100 Choice d. (Joe’s observations were not reproduced by others.)
101 Choice c. (Galileo.)
102 Choice e. (a neutron star in a binary system.)
103 Choice b. (change the direction and speed of the probe without using rockets.)
104 Choice a. (planets appearing to move backwards relative to the distant stars in relation to their usual motion.)
105 Choice d. (of dazzling brightness.)
106 Choice b. (an eclipse of the Moon.)
107 Choice b. (inclined at an angle to the perpendicular that is similar to Earth’s rotation axis.)
108 Choice b. (Jupiter)
109 Choice a. (nothing because a sterilized control sample gave the same result.)
110 Choice e. (100,000 parsecs.)
111 Choice a. (Pluto.)
112 Choice c. (Venus)
113 Choice a. (the rapid fluctuations in its X-rays.)
114 Choice c. (essentially zero.)
115 Choice c. (This model incorrectly predicts planets orbiting out of the plane of the Sun’s equator.)
116 Choice d. (the bullet.)
117 Choice c. (a family of moons, all orbiting in the plane of the planets equator.)
118 Choice b. (at the back of the telescope.)
119 Choice e. (absolute magnitude is known.)
120 Choice a. (The model predicts rocky planets nearest to the Sun and we observe rocky planets there.)
Where to find these questions in the lecture notes

1. EModule 017.304 Earth Impacts Large Object Impacts EC4
2. Module 024.502 The Hertzsprung-Russell Diagram, Spectroscopic Parallax
3. Module 011.423 The Terrestrial Planets Moon Space Probes
4. Module 020.302-g01 Stellar Parallax and Distance What Causes Parallax?
5. Module 019.414 The Search for Life Extrasolar Planets
6. ***Module 017.402 Earth Impacts Hunting Killer Asteroids 28%
7. Module 007.502-g01 Science Model Building Phases of the Moon
8. ***Module 026.203-g01 The Quiet Deaths of Ordinary Stars, Second Chance 048.23(23%)
9. Module 013.101-g01 Comets and the Outer Solar System Comets in Detail
10. EModule 020.406-g01 Stellar Parallax and Distance Parallax Angle and Distance QR2
11. *Module 007.505 Science Model Building Phases of the Moon (38%)
12. Module 019.411-g01 The Search for Life Extrasolar Planets
13. Module 024.102C The Hertzsprung-Russell Diagram, A dot for each star
14. Module 019.306 The Search for Life The Jovian Moons
15. Module 012.202-g01 The Jovian Planets Saturn Surface
17. Module 009.101-g01 Science Models of Gravity Explaining Kepler’s Laws
18. Module 003.402-g01 The Sky: Celestial Sphere Apparent Motion of the Sun
20. **EModule 017.406-g01 Earth Impacts Hunting Killer Asteroids (32%) RA1
21. Module 007.202-g01 Science Model Building Earth-Moon System
22. EModule 016.101 Earth’s Living Surface An Active Crust (F2011393%,89%,84%,94%,91%,87%) EC2
25. Module 013.401 Comets and the Outer Solar System The Transition from Kuiper Belt to Oort Cloud
26. Module 020.407-g01 Stellar Parallax and Distance Parallax Angle and Distance
27. Module 006.302-g01 Science Scientific Statements The Search for Error
28. Module 018.103 Requirements for Life Light
29. Module 005.102 The Sky: Power of Observation Big Science
30. Module 011.403 The Terrestrial Planets Moon Surface Features
31. Module 018.406 Requirements for Life The Energy Sources of Life
32. Module 016.504 Earth’s Living Surface Comparing Earth to Other Planets
33. Module 011.418-g01 The Terrestrial Planets Moon Oddities of the Moon Formation of the Moon
34. Module 015.102 Earth’s Atmosphere and Interior A Thin Layer of Air
35. Module 015.506-g01 Earth’s Atmosphere and Interior The Earth’s Interior
36. Module 010.102-g01 Solar System Overview The Big Picture
37 Module 016.106 Earth’s Living Surface An Active Crust
38 EModule 008.516 Science Models of Motion Force and Mass \( a = F/m \) QR1
39 Module 025.403 Evolution onto the Main Sequence (047.33)
40 Module 021.108 Using the Doppler Shift Describing Waves
41 EModule 024.201 The Hertzsprung-Russell Diagram, Interpreting the diagram QR3
42 Module 014.204-g01 Formation of the Solar System The Protostar Stage
43 Module 025.101-g01 The Building Blocks of Matter (042.11)
44 Module 026.302-g01 The Quiet Deaths of Ordinary Stars, The Red Supergiant Stage 048.32
45 EModule 018.505 Requirements for Life Reproduction (F20113:89%) EC3
46 *Module 001.103-g01 The Sky: As Certain as the Sunrise. Observation (36%)
47 Module 018.305 Requirements for Life The Requirements for a Carbon Cycle
48 Module 011.101-g01 The Terrestrial Planets Mercury Surface
49 Module 003.303 The Sky: Celestial Sphere Star Motions
50 ***Module 029.509 The Milky Way Galaxy, The Monster in the Core (055.33) (24%)
51 Module 010.201 Solar System Overview The Terrestrial Planets
52 Module 029.102 The Milky Way Galaxy, How We See it (052.12)
53 Module 008.505 Science Models of Motion Force and Mass \( F=ma \)
54 Module 008.202-g01 Science Models of Motion The Law of Inertia
55 **Module 011.415 The Terrestrial Planets Moon Oddities of the Moon Formation of the Moon (29%)
56 Module 005.504 The Sky: Power of Observation Kepler’s First Law
57 Module 009.401 Science Models of Gravity Unifying Physical Law
58 Module 009.602-g01 Science Models of Gravity Artificial Satellites
59 Module 007.510 Science Model Building Phases of the Moon
60 Module 008.503-g01 Science Models of Motion Force and Mass (F20113:73%)
61 Module 012.402 The Jovian Planets Neptune Surface
62 Module 012.222 The Jovian Planets Saturn Space Probes
63 Module 025.504 Stars of Extreme Mass (047.44)
64 Module 016.304-g01 Earth’s Living Surface The Carbon Cycle
65 *Module 019.503 The Search for Life SETI: Search for ExtraTerrestrial Intelligence(37%)
66 Module 003.208 The Sky: Celestial Sphere Pointer Stars
67 *Module 003.403 The Sky: Celestial Sphere Apparent Motion of the Sun (38%)
68 EModule 015.403 Earth’s Atmosphere and Interior Greenhouse Effect EC5
69 *Module 018.103-g02 Requirements for Life Light (40%)
70 *Module 022.103 Stellar Magnitudes and Distance Luminosity, Brightness and Distance (35%)
71 **Module 004.401-rev The Sky: Wandering Planets Copernicus doubts (?)
72 Module 021.202 Using the Doppler Shift The Doppler Shift
73 *Module 011.104-g01 The Terrestrial Planets Mercury Surface (38%)
74 Module 022.201-g01 Stellar Magnitudes and Distance Luminosity, The Magnitude Scale
75 Module 027.201 Supernova Explosions, Payback Time 049.31
76 Module 017.104 Earth Impacts Near Earth Objects
77 Module 026.401 The Quiet Deaths of Ordinary Stars, Game Over: Everybody leaves 048.41 (43%)
78 Module 007.401 Science Model Building Time and Compass Heading
79 Module 001.102 The Sky: As Certain as the Sunrise. Where?
80 Module 025.303 Ignition (042.33)
81 **Module 013.402-g01 Comets and the Outer Solar System The Transition from Kuiper Belt to Oort Cloud (24%)
82 Module 021.110 Using the Doppler Shift Describing Waves
83 Module 018.501 Requirements for Life Reproduction
84 Module 029.201 The Milky Way Galaxy, How we Measure Distances Within It (052.31)
85 Module 025.201-g01 Mass and Energy (042.21)
86 **Module 021.304 Using the Doppler Shift Binary Systems (33%)
87 Module 012.117 The Jovian Planets Jupiter Moons
88 Module 018.201 Requirements for Life The Chemical Basis of Life
89 ***Module 012.211-g01 The Jovian Planets Saturn Magnetic Field (27%)
90 EModule 006.102 Science Scientific Statements How to test a statement (?) CT2
91 Module 011.520 The Terrestrial Planets Mars Space Probes
92 Module 029.508 The Milky Way Galaxy, The Monster in the Core (055.32)
93 Module 007.604 Science Model Building Phases of Venus
94 Module 020.404 Stellar Parallax and Distance Parallax Angle and Distance (F20113:70%)
95 Module 028.301 Collapsed Objects, Black Holes 051.11
96 Module 012.317 The Jovian Planets Uranus Space Probes
97 Module 019.507 The Search for Life SETI: Search for ExtraTerrestrial Intelligence (42%)
98 Module 023.101-g01 Star Colors and Classes, Colors and Temperatures
99 Module 011.504-g01 The Terrestrial Planets Mars Surface
100 EModule 001.202 The Sky: As Certain as the Sunrise. Reproducible CT1
101 Module 008.401-g01 Science Models of Motion The Universality of Free Fall
102 Module 028.202 Collapsed Objects, X-Ray Sources 050.32
103 Module 011.114 The Terrestrial Planets Mercury Space Probes
104 Module 004.102-g01 The Sky: Wandering Planets Retrograde motion
105 Module 022.304-g01 Stellar Magnitudes and Distance Luminosity, Apparent and Absolute Magnitudes
106 ***Module 007.203 Science Model Building Earth-Moon System (25%)
107 Module 012.209 The Jovian Planets Saturn Orbit and Rotation
108 Module 012.108 The Jovian Planets Jupiter Surface
109 Module 019.207 The Search for Life Mars
Module 022.403 Stellar Magnitudes and Distance Luminosity, Finding the distance
Module 010.604 Solar System Overview The Kuiper Belt (45%)
**Module 011.208 The Terrestrial Planets Venus Magnetic Field (31%)
*Module 028.404 Collapsed Objects, Detecting Black Holes 051.24 (40%)
**Module 011.511 The Terrestrial Planets Mars Magnetic Field (32%)
***Module 014.106-g01 Formation of the Solar System The Solar Nebula (20%)
Module 008.604 Science Models of Motion Action and Reaction
Module 010.304-g01 Solar System Overview The Jovian Planets
Module 020.201-g01 Stellar Parallax and Distance Telescopes
Module 022.501 Stellar Magnitudes and Distance Luminosity, Preview of the Distance Ladder
Module 014.301-g01 Formation of the Solar System Condensation of the Planets