1 The newspaper says that the Moon was full last night. That statement is most likely
   a. an unsupported opinion of the newspaper editor.
   b. an actual observation of the natural world.
   c. a proven mathematical theorem.
   d. based on some authoritative reference such as the U.S. Naval Observatory.

2 The first major failure of the Ptolemaic Theory to predict the results of observations was
   a. the retrograde motion of the planets.
   b. the Moons of Jupiter.
   c. the mountains of the Moon.
   d. the phases of Venus.
   e. the precise observations of Tycho Brahe.

3 Our Sun is a G2V star with absolute magnitude 4.8. Suppose that a star of spectral type G2V is observed to have apparent magnitude −0.2. How far away is it?
   a. 10 parsecs.
   b. 5 parsecs.
   c. 1 parsec.
   d. 1000 parsecs.
   e. 100 parsecs.

4 Planets move mostly eastward relative to the distant stars but, once during each trip around the Celestial Sphere, they loop back westward for a while. This motion is called
   a. overtaking behavior.
   b. planetary reversal.
   c. retrograde motion.
   d. paradoxical motion.
   e. epicyclic motion.

5 Which of the following temperatures would be most likely at noon on the hottest day of the year in the warmest part of Mars?
   a. 100F.
   b. 50F.
   c. -200F.
   d. -150F.

6 A horse is pulling a cart along a road. Which of the following pairs of forces is an action-reaction pair?
   a. The force of the horse on the cart and the force of the horse on the road.
   b. The force of the horse on the cart and the force of the road on the horse.
   c. The force of the cart on the horse and the force of the road on the horse.
   d. The force of horse on the road and the force of the road on the horse.
   e. The force of the cart on the horse and the force of the horse on the road.

7 A star is seen to move by 0.8 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. 0.3 seconds of arc.
   b. 0.4 seconds of arc.
   c. 0.8 seconds of arc.
   d. 0.1 seconds of arc.
   e. 0.2 seconds of arc.
8 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. 410nm and 434nm
   c. 400nm and 424nm

9 Which of the following spectral types would you expect to look blue in color?
   a. F.   b. A.   c. G...   d. M.

10 Milankovich cycles refer to
   a. changes in the intensity of sunlight due to shifts in both the Earth’s orbit and rotation axis.
   b. changes in the intensity of sunlight due to shifts in the atmosphere of the Sun and the Earth’s rotation axis.
   c. the regular shifting of the Earth’s rotation axis.
   d. changes in the intensity of sunlight due to shifts in the Earth’s orbit.
   e. the regular shifting of the Earth’s orbit.

11 The reason that the Crab Pulsar is slowing down is
   a. that it is getting older.
   b. tidal friction due to the gravity of a nearby star.
   c. that it is losing electric charge.
   d. that it is running out of nuclear fuel.
   e. its magnetic field is dragging through nearby gas.

12 As seen from far above the Earth’s North Pole, the Earth orbits the Sun counter clockwise and
   a. Mercury orbits the Sun clockwise.
   b. No planet orbits the Sun clockwise.
   c. Venus orbits the Sun clockwise.
   d. the Jovian planets orbit the Sun clockwise.

13 Which of Kepler’s Laws compares the speeds of different planets?
   a. The Law of Averages.
   b. Orbits are Ellipses.
   c. The Equal Area Law.
   d. The Law of Inertia.
   e. The Period-Radius Relation.

14 You would expect to see a waning crescent Moon
   a. Setting in the West right after the Sun.
   b. Rising in the East just before the Sun.
   c. In the North at around midnight.
   d. Rising in the West just before the Sun.
   e. Setting in the East right after the Sun.

15 To measure the heliocentric stellar parallax of a star, you mostly need a telescope with
   a. high magnification power.
   b. high resolving power.
   c. large light collecting power.
16 An example of a planet which may occasionally have liquid water but retains an atmosphere of mostly carbon dioxide is
   a. Earth
   b. Venus
   c. Mercury
   d. Mars

17 The number of objects that have been observed to be orbiting in the Kuiper Belt is approximately
   a. 0.
   b. 1000.
   c. 1.
   d. 25.

18 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 planet.
   d. a yellow dwarf.
   e. a class M object.

19 Based on our observations of planetary systems that are forming now, which of these situations is LEAST likely to occur on a planet in a distant binary star system?
   a. You see two suns, both of them looking similar in size to our own Sun, in widely separated parts of the sky.
   b. You see two suns, both looking similar in apparent size to our own Sun, and both staying close together in the sky at all times.
   c. You see two suns in the sky, one looking similar in apparent size to our own Sun and the other a point of light like a very bright star.

20 On Earth, a stable carbon cycle could not exist without
   a. plants turning carbon dioxide into organic material.
   b. animals breathing out carbon dioxide.
   c. the decay of dead plant matter.
   d. plate tectonics recycling the sea floor into the Earth’s interior.
   e. the burning of fossil fuels.

21 For a planet to have substantial amounts of liquid water on its surface, it must have
   a. atmospheric pressure exactly at the triple point of water.
   b. both temperature and atmospheric pressure at the triple point of water.
   c. atmospheric pressure above the triple point of water.
   d. temperature above the triple point of water.
   e. temperature between 0°C and 100°C.

22 The diameter of a white dwarf star might be
   a. 10,000 miles.
   b. 100,000,000 miles.
   c. 1,000,000 miles.
   d. 10 miles.
23 Spectroscopic Parallax refers to
   a. a method for finding distances to stars.
   b. the pressure broadening of spectral lines.
   c. the use of stellar parallax.
   d. the shifting of spectral lines due to star motion.

24 Which of the following objects has a magnetic field similar in intensity to the Earth’s field?
   a. Earth’s Moon
   b. Saturn
   c. Mars
   d. Jupiter
   e. Mercury

25 The mass of a carbon atom is 12.00amu while the mass of a deuterium atom is 2.014amu. If six deuterium atoms fuse to form a carbon atom, how much mass is converted into energy?
   a. 0.009amu
   b. 0.168amu
   c. 0.084amu
   d. 0.014amu
   e. 0.056amu

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

27 Call the time it takes Venus to orbit the Sun a “venusian year.” Call the time it takes Venus to rotate once on its axis relative to the distant stars a “venusian sidereal day.” Which of the following statements about these two time periods is true?
   a. A venusian year is exactly 1.5 venusian sidereal days.
   b. A venusian year is shorter than a venusian sidereal day.
   c. A venusian year is exactly one venusian sidereal day.
   d. A venusian year is exactly 2 venusian sidereal days.

28 The asteroid 2008 AF4 has one chance in 21,000 of hitting the Earth between the years 2078 and 2100. The asteroid is 390 meters in diameter compared to 250 meters in diameter for Apophis. Assuming that an impact could cause the death of 30,000,000 people the average death rate for this type of event is approximately
   a. 1500 people per event.
   b. 500 people per event.
   c. 2500 people per event.
   d. 3000 people per event.
   e. 2000 people per event.
29 As seen from North America, the constellation Orion
   a. never sets.
   b. sets in the northeast.
   c. sets in the west and southwest.
   d. sets in the east and southeast.
   e. sets in the northwest.

30 It has been theorized that planets do not easily form in binary star systems. If they do form, there are three possible arrangements: (1) Planets with orbits similar in radius to the distance between the two stars. (2) Planets with orbits much smaller in radius than the distance between the two stars. (3) Planets with orbits much larger in radius than the distance between the two stars. Observations so far (2009) indicate that
   a. none of these possibilities actually happens.
   b. possibilities (1) and (2) actually happen.
   c. possibilities (1) and (3) actually happen.
   d. all of these possibilities actually happen.
   e. possibilities (2) and (3) actually happen.

31 High protostellar winds of ejected gas occur when the protostar is in the
   a. Tau Ceti phase.
   b. main sequence phase.
   c. photosphere formation phase.
   d. nuclear ignition phase.
   e. Tau Tauri phase.

32 Sven, a well-known Loch Ness Monster fanatic, often reports seeing the monster but is usually ignored. One evening, while watching the monster swim around in the light of the setting sun, Sven notices that the tide is out and there is a quarter Moon in the sky. He tells this story to a newspaper reporter who humors him and shows up to look for the monster the next time there is a low tide at sunset with a quarter moon. Sure enough, the monster appears. A local university then sends a biologist with a truckload of cameras at the next sunset-low-tide-quarter-moon and the monster again shows up on cue. Sven’s observations of the monster are now accepted by the scientific community because
   a. Scientists really like monster stories.
   b. Sven saw the monster many times.
   c. Sven’s observations were reproduced by others.
   d. Sven told a good story with lots of details.

33 When an arrow is fired from a bow, the arrow keeps moving after it leaves the bow because
   a. the displaced air pushes it from behind.
   b. the force of the bow keeps acting on it.
   c. no force stops it.
   d. the force of its inertia pushes it.
   e. it is pointed at the front and has fins at the back.
34 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 3\textsuperscript{rd} century BCE by
   a. Aristarchus of Samos
   b. Aristotle.
   c. Selucus of Seleucia.
   d. Eratosthenes of Cyrene.
   e. Claudius Ptolemaeus.

35 As of 2009, how many space probes have flown past Uranus?
   a. 1.  b. 4.  c. 0.  d. 3.  e. 2.

36 Stellar Parallax is caused by
   a. the motion of our Sun relative to its neighbors.
   b. the actual motion of stars relative to their neighbors.
   c. turbulence in the Earth’s atmosphere.
   d. the finite speed of light.
   e. the motion of the Earth around the Sun.

37 Relative to the Milky Way family of stars, our sun is
   a. Neither at the center nor at the edge.
   b. At the center.
   c. At the extreme edge.

38 Suppose that the U.S. Naval Observatory published a table saying that the Moon rose at 6:45pm 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.

39 Satellites such as the International Space Station orbit above most of the Earth’s atmosphere because
   a. gravity does not extend beyond the atmosphere, so there is no gravity to pull the satellite down.
   b. it avoids creating sonic booms that would annoy people.
   c. then the top of the atmosphere can support the satellite.
   d. there is no air friction to slow the satellite down.

40 The stars of the Milky Way are all near a great circle on the Celestial Sphere. This great circle
   a. is the Celestial Equator.
   b. passes through the Celestial Poles.
   c. is none of the other things listed here.
   d. is the Ecliptic.

41 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 clockwise. The part of the Earth that is directly below you must be the Earth’s
   a. North Pole.
   b. South Pole.
   c. Equator.
42 The Outer Oort Cloud is
a. distributed along the rotation axis of the solar system.
b. a doughnut-shaped region with objects above and below the plane of the solar system.
c. distributed in all directions.
d. a belt of objects mostly in the plane of the solar system.

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

44 The star Vega is 25 parsecs from our Sun. The light from Vega has been traveling for about
a. 7.5 years.
b. 0.04 years.
c. 80 years.
d. 12.5 years.
e. 25 years.

45 The first major failure of the Ptolemaic Theory to predict the results of observations was
a. the retrograde motion of the planets.
b. the Moons of Jupiter.
c. the mountains of the Moon.
d. the phases of Venus.

46 In the Hertzsprung-Russell Diagram shown, which point represents a star of type F with absolute magnitude -5?

![Hertzsprung-Russell Diagram](image)

47 The reason that most SETI programs choose to listen at microwave radio frequencies is that
a. microwaves can be beamed in a single direction.
b. microwaves are the most energy efficient way to send information.
c. microwave receivers are easy to build.
d. microwaves can get through our atmosphere without being absorbed.

48 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.
49 Our Sun’s location in the Milky Way is closest to the
   a. Cygnus Arm.
   b. Orion Arm.
   c. Sagittarius Arm.
   d. Norma Arm.
   e. Scutum-Crux Arm.

50 One observation that we are fairly sure helped to convince the Greeks that the Earth is spherical rather than flat is
   a. that people on the far side of the Earth are upside-down.
   b. constellations that could be seen from Egypt but not from Greece.
   c. stories of endless nights at the North Pole.
   d. the fact that maps of very large regions would not fit on a flat sheet of paper.

51 It has been said that the “facts” of science are actually “revisable facts.” When do these “revisable facts” get revised?
   a. They are successfully challenged in court.
   b. A scientific professional society votes them out.
   c. More elegant “revisable facts” are discovered.
   d. They conflict with reproducible observations.
   e. They are on the losing side of a debate.

52 According to the definition of "habitable zone" that we are using, Earth is
   a. at the center of the habitable zone of our Solar System.
   b. near the outer edge of the habitable zone of our Solar System.
   c. near the inner edge of the habitable zone of our Solar System.
   d. no longer in the habitable zone of our Solar System.

53 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 dazzling brightness.
   b. visible only with a telescope.
   c. barely visible to the naked eye.
   d. of average naked-eye brightness.

54 Which of the following statements is falsifiable?
   a. Some people own green cell phones.
   b. Green cell phones are really ugly.
   c. Everybody owns a green cell phone.

55 A very large number of new asteroids have been discovered since 1990 primarily because
   a. space probes have been used to look for them.
   b. telescopes started using digital imaging instead of film.
   c. orbiting infrared observatories have been used to look for them.
   d. more astronomers have been looking for them.

56 Which of the following objects is a moon of Jupiter?
57 So far (as of 2008), the planet Venus has been visited by
   a. two or three successful space probes.
   b. about 48 successful space probes.
   c. about 20 successful space probes.
   d. no successful space probes.
   e. just one successful space probe.

58 Water ice can be found on all but one of these planets. Which one has no ice?
   a. Venus
   b. Mars
   c. Mercury
   d. Earth

59 What total force will cause an object with a mass of 5kg to gain 10 meters per second every second?
   a. 5 Newtons.
   b. 50 Newtons.
   c. 10 Newtons.
   d. 490 Newtons.
   e. 9.8 Newtons.

60 The absorption and re-radiation of infrared light by gases such as carbon dioxide is the key process in the
   a. creation of the ionosphere.
   b. destruction of the ozone layer.
   c. Greenhouse Effect.
   d. Stark Effect.
   e. creation of smog.

61 Kepler found that the orbit of Mars is best described as
   a. an ellipse.
   b. a circle with the Sun at the center.
   c. a complicated fourth-order polynomial curve.
   d. a circle with the Sun off-center, combined with epicycles.

62 The average radius of the Earth’s orbit is
   a. 0.01 au.
   b. 2.0 au.
   c. 1.0 au.
   d. 0.1 au.
   e. 5 au.

63 The key advantage of Carbon over Silicon as the basic element for life is that
   a. carbon can combine with hydrogen and silicon cannot.
   b. carbon atoms can bond to other carbon atoms but silicon atoms cannot bond to other silicon atoms.
   c. carbon is more abundant than silicon.
   d. carbon forms more stable compounds than silicon.
   e. carbon-based life got started first.
64 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 planets equator.

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

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

67 A normal Helium nucleus consists of two protons and two neutrons. The protons actually repel each other because they have the same charge. The main force that holds this nucleus together is
   a. the weak force.
   b. the force of gravity.
   c. the strong force.
   d. the electrical force.

68 Consider a planet that is similar to Earth in size and Mass with a semiliquid interior. According to our current understanding, which of the following things is also necessary for that planet to have active plate tectonics?
   a. The core temperature should be much higher than the surface temperature.
   b. The amount of liquid surface water should be the same as on Earth.
   c. The core temperature should be much lower than the surface temperature.
   d. The intensity of sunlight should be the same as on Earth.
   e. The core temperature should be the same as the surface temperature.

69 Consider a light source whose absolute magnitude can be deduced from the properties of the light that reaches us from that source. Astronomers often refer to this sort of object as a
   a. reference object.
   b. distance marker.
   c. spectroscopic standard.
   d. brightness reference.
   e. standard candle.

70 Which of the following computer programs is the most likely to be considered a scientific model?
   a. An animated screen-saver that shows waves crashing on the beach.
   b. A simulation game in which people can spend a day at the beach.
   c. A simulation, using currently accepted physical laws, of waves crashing on the beach.
71 On the present Earth, the portable source of carbon that plants use to build complex organic compounds is
   a. graphite.
   b. other plants.
   c. methane.
   d. carbon dioxide.
   e. coal.

72 In an evolved high-mass star, when the electrons combine with protons to form a pure neutron core, the reaction
   a. generates a gamma ray burst.
   b. generates an X-ray burst.
   c. absorbs gamma rays.
   d. absorbs neutrinos.
   e. generates a neutrino burst.

73 Barnard's Star shows a heliocentric stellar parallax near 1/2 seconds of arc. The distance from our Sun to Barnard's Star is
   a. 0.75      b. 0.25      c. 2      d. 4      e. 8
   parsecs.

74 Which of the following temperatures is closest to what you might expect on the planet Uranus?
   a. 100°F
   b. -150°F
   c. 50°F
   d. -250°F
   e. -350°F

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

76 The Viking Landers carried out several experiments on Martian surface soil in order to detect the presence of life. Those same experiments were also carried out on a control sample of Martian surface soil that had been sterilized by heat. The purpose of doing experiments on the control sample was to
   a. avoid getting a false positive result.
   b. avoid getting a false negative result.
   c. make sure the lander was working properly.
   d. calibrate the landers' instruments.

77 Aristarchus measured the angle between the Sun and the Moon when exactly half of the Moon was illuminated. If he had measured the angle when 3/4 of the Moon was illuminated, he would have found that angle to be
   a. greater than 90 degrees.
   b. less than 90 degrees by an amount that was easy for him to measure.
   c. exactly 90 degrees.
   d. less than 90 degrees by an amount too small for him to measure.
78. At 10pm, you see that the pointer stars of the Big dipper and the star Polaris are arranged in a vertical line. How long, give or take a few minutes, would you need to wait to see them arranged in a horizontal line?
   a. 6 hours.
   b. 3 hours.
   c. 24 hours.
   d. It will never happen.
   e. 12 hours.

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

80. Which of the following substances is the smallest fraction of our atmosphere?
   a. Carbon Dioxide
   b. Water
   c. Nitrogen
   d. Oxygen
   e. Argon

81. The wavelength of the sound waves that correspond to middle-C is about 4 feet. If you are standing 8 feet away from a piano that is playing that note, then between you and the piano there will usually be
   a. maximum pressure every two seconds.
   b. maximum pressure every four seconds.
   c. one region of maximum pressure.
   d. three regions of maximum pressure.
   e. two regions of maximum pressure.

82. The angle between a planet’s rotation axis and the perpendicular to the plane of its orbit determines the variability of its seasons. For Jupiter, this axial tilt angle is
   a. similar to Uranus so that seasons are extreme.
   b. zero so that seasons do not exist.
   c. only a few degrees so seasons are negligible.
   d. similar to Earth so that seasons are very noticeable.

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

84. For an object that is moving along a straight path, the acceleration is
   a. zero.
   b. the distance the object travels divided by the time it takes.
   c. the time the object is moving divided by the change in its speed during that time.
   d. the time the object is moving divided by the distance it travels during that time.
   e. the change in the object’s speed divided by the time it takes.
85 Galileo predicted that dropping a wooden ball and an iron ball at exactly the same time would result in them hitting the ground at the same time, so long as air friction was negligible. When he actually did the experiment, the balls hit the ground very close together, but sometimes the wooden ball hit first and sometimes the iron one hit first. If we repeat his experiment today, we find exactly the same thing. Which of the following conclusions is appropriate?
   a. Galileo’s theory was not disproven because the slight differences can be explained by defects in the experiment.
   b. Galileo did not really do the experiment.
   c. Galileo’s theory was disproven since his prediction did not exactly correspond to observation.

86 The semiliquid rock that is found inside the Earth
   a. is a liquid suspended in a solid.
   b. flows like a liquid under gradual pressure but is stiff like a solid under sudden pressure.
   c. flows like a liquid under sudden pressure but is stiff like a solid under gradual pressure.
   d. is a solid suspended in a liquid.

87 In the Earth’s atmosphere, the percentage that is water vapor is roughly
   a. 50%.
   b. 80%.
   c. 20%.
   d. 0.04%.
   e. 1%.

88 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.

89 A large vortex or hurricane on Jupiter has been named
   a. The Red Storm.
   b. Jove’s Eye.
   c. The Great Red Spot.
   d. The Great Dark Spot.

90 We can use the pointer stars in the Big Dipper to locate a point in the sky near the
   a. South Celestial Pole.
   b. Star Sirius.
   c. East Celestial Pole.
   d. North Celestial Pole.
   e. Celestial Equator.

91 Compared to the frequency of photons absorbed during a transition from a -6ev state to a -4ev state, transitions from the -5ev state to a -3ev state would correspond to absorbing photons whose frequency is
   a. 3 times as high.
   b. 5 times as high.
   c. 2 times as high.
   d. the same.
   e. 4 times as high.
92 A star is found to have absolute magnitude 4 and apparent magnitude 24. How far away is it?
   a. 100,000 parsecs.
   b. 10,000 parsecs.
   c. 10 parsecs.
   d. 200 parsecs.
   e. 20 parsecs.

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

94 When Newton calculated the magnitude and direction of the acceleration for a planet that was following Kepler’s Laws, he found that the direction of the acceleration was
   a. away from the Sun.
   b. toward the Sun.
   c. in the direction of the planets motion.
   d. opposite to the direction of the planets motion.
   e. between the direction of the planets motion and the direction from the planet to the Sun.

95 The Kuiper Belt is thought to have originated when
   a. a planet failed to form near Jupiter.
   b. icy objects were ejected inward from among the Jovian planets.
   c. icy objects were ejected outward from among the Jovian planets.
   d. icy objects condensed out of the interstellar medium.
   e. icy objects condensed out just beyond Neptune.

96 The density of water is 1000kg/m³ while the density of iron is 7800kg/m³. Which of the following values is a plausible value for the density of a terrestrial planet?
   a. 1000kg/m³
   b. 5000kg/m³
   c. 10,000kg/m³
   d. 20,000kg/m³
   e. 500kg/m³

97 The first successful soft landing on the Moon was
   c. Surveyor 1 in 1969.
   e. Luna 21 in 1976.
98 A DNA molecule consists of
   a. two long chains of nitrogenous bases connected by sugar phosphate molecules.
   b. two sugar phosphate chains connected by pairs of nitrogenous bases.
   c. two sugar phosphate chains connected by single amino acids.
   d. two long chains of amino acids connected by pairs of sugar phosphate molecules.

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

100 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. no magnetic field at all because its density indicates only a small iron core.
   c. a magnetic field similar to Earth’s because it is a terrestrial planet.
   d. a much larger magnetic field because of its huge iron core.

101 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 2000kg (including the sail) and sunlight exerts a total force of 10N on the sail. What will be the
acceleration of the spacecraft?
   a. 10m/s².
   b. 20,000m/s².
   c. 2000m/s².
   d. 5m/s².
   e. 0.005m/s².

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

103 Which of the following systems do most living things on Earth now use to reproduce themselves?
   a. Each enzyme acts as a pattern to make copies of itself.
   b. Each DNA molecules splits in half and each half acts as a pattern to complete its other half.
   c. Each RNA molecules acts as a pattern to make copies of itself.

104 The Moon rotates on its axis relative to the distant stars
   a. not at all.
   b. once a year.
   c. once every sidereal month.
   d. once every sidereal day.
105 Saturn has
   a. an atmosphere of carbon dioxide with about 90 times the surface pressure of Earth’s.
   b. an atmosphere of carbon dioxide with about 1% the surface pressure of Earth’s.
   c. an atmosphere of Hydrogen and Helium with some methane.
   d. an atmosphere of Hydrogen and Helium with no real surface.
   e. almost no atmosphere.

106 Which of the following spacecraft went into orbit around Mars only to find the surface totally obscured by a planet-wide dust storm?
   a. Mariner 10
   b. MESSENGER
   c. Mariner 9
   d. Pioneer 10
   e. Pioneer 11

107 Which of the following magnitudes corresponds to the brightest star?
   a. +2.6
   b. +4.1
   c. +1.2
   d. +1.0
   e. +4.2

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

109 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. 4 light years.
   b. 0.04 light years.
   c. 0.004 light years.
   d. 4000 light years.
   e. 40 light years.

110 The Asteroid Belt is between the orbits of
   a. Mars and Jupiter.
   b. Jupiter and Uranus.
   c. Neptune and Pluto.
   d. Earth and Mars.
   e. Jupiter and Saturn.
111 Which of these moons has landmarks that are not rotating with the rest of the moon, indicating a subsurface ocean?
   a. Europa.
   b. Ganymede.
   c. Enceladus.
   d. Titan.

112 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 2, how far away is it?
   a. 10 parsecs.
   b. 1000 parsecs.
   c. 100 parsecs.
   d. 5 parsecs.
   e. 50 parsecs.

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

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

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

116 When Newton’s Laws were applied to predict the exact motion of the planet Uranus, the prediction failed to agree with very precise measurements. This failure led to the discovery
   a. of the Planet Pluto.
   b. an invisible moon of Uranus.
   c. that Newton’s Theory of Gravity is not correct.
   d. that the Sun wobbles.
   e. of the Planet Neptune.
117 The Earth is farther from the Sun than Mercury. Which of the following statements is true?
   a. The Earth takes less time to go around the Sun and moves a lot faster than Mercury.
   b. The Earth takes more time to go around the Sun and also moves slower than Mercury.
   c. The Earth takes more time to go around the Sun but moves faster than Mercury because it has farther to go.
   d. The Earth takes less time to go around the Sun and moves slower than Mercury.

118 In the Hertzsprung-Russell diagram shown, point number 5 could be a

![Hertzsprung-Russell Diagram](image)

   b. B0 star of absolute magnitude -5.
   c. F0 star of absolute magnitude -5.
   d. F9 star of absolute magnitude 5.
   e. B0 star of absolute magnitude 10.

119 You see a reflecting telescope with a short, stubby tube and the eyepiece at the back. This telescope uses the
   a. Cassegrain Focus.
   b. Prime Focus.
   c. Coudé Focus.
   d. Newtonian Focus.

120 An annual meteor shower occurs when
   a. our Sun passes through a spiral arm.
   b. a nearby star explodes.
   c. the Solar Wind hits the Earth’s atmosphere.
   d. asteroids hit the Earth.
   e. the Earth passes through comet debris.
Answer Key: Spring 2018 FX-04

1. Choice d. (based on some authoritative reference such as the U.S. Naval Observatory.)
2. Choice d. (the phases of Venus.)
3. Choice c. (1 parsec.)
4. Choice c. (retrograde motion.)
5. Choice b. (50F.)
6. Choice d. (The force of horse on the road and the force of the road on the horse.)
7. Choice b. (0.4 seconds of arc.)
8. Choice c. (400nm and 424nm)
9. Choice b. (A.)
10. Choice a. (changes in the intensity of sunlight due to shifts in both the Earth’s orbit and rotation axis.)
11. Choice e. (its magnetic field is dragging through nearby gas.)
12. Choice b. (No planet orbits the Sun clockwise.)
13. Choice e. (The Period-Radius Relation.)
14. Choice b. (Rising in the East just before the Sun.)
15. Choice b. (high resolving power.)
16. Choice d. (Mars)
17. Choice b. (1000.)
18. Choice b. (a brown dwarf.)
19. Choice a. (You see two suns, both of them looking similar in size to our own Sun, in widely separated parts of the sky.)
20. Choice d. (plate tectonics recycling the sea floor into the Earth’s interior.)
21. Choice c. (atmospheric pressure above the triple point of water.)
22. Choice a. (10,000 miles.)
23. Choice a. (a method for finding distances to stars.)
24. Choice b. (Saturn)
25. Choice c. (0.084amu)
26. Choice b. (have similar periods.)
27. Choice b. (A venusian year is shorter than a venusian sidereal day.)
28. Choice a. (1500 people per event.)
29. Choice c. (sets in the west and southwest.)
30. Choice e. (possibilities (2) and (3) actually happen.)
31. Choice e. (Tau Tauri phase.)
32. Choice c. (Sven’s observations were reproduced by others.)
33. Choice c. (no force stops it.)
34. Choice d. (Eratosthenes of Cyrene.)
35. Choice a. (1.)
36 Choice e. (the motion of the Earth around the Sun.)
37 Choice a. (Neither at the center nor at the edge.)
38 Choice d. (the result of a calculation.)
39 Choice d. (there is no air friction to slow the satellite down.)
40 Choice c. (is none of the other things listed here.)
41 Choice b. (South Pole.)
42 Choice c. (distributed in all directions.)
43 Choice c. (small changes in starlight due to planetary transits.)
44 Choice c. (80 years.)
45 Choice d. (the phases of Venus.)
46 Choice c. (C)
47 Choice b. (microwaves are the most energy efficient way to send information.)
48 Choice b. (Europa.)
49 Choice b. (Orion Arm.)
50 Choice b. (constellations that could be seen from Egypt but not from Greece.)
51 Choice d. (They conflict with reproducible observations.)
52 Choice c. (near the inner edge of the habitable zone of our Solar System.)
53 Choice a. (of dazzling brightness.)
54 Choice c. (Everybody owns a green cell phone.)
55 Choice b. (telescopes started using digital imaging instead of film.)
56 Choice c. (Callisto)
57 Choice c. (about 20 successful space probes.)
58 Choice a. (Venus)
59 Choice b. (50 Newtons.)
60 Choice c. (Greenhouse Effect.)
61 Choice a. (an ellipse.)
62 Choice c. (1.0 au.)
63 Choice d. (carbon forms more stable compounds than silicon.)
64 Choice c. (a family of moons, all orbiting in the plane of the planets equator.)
65 Choice d. (27 days.)
66 Choice a. (the noon sun is highest in the sky.)
67 Choice c. (the strong force.)
68 Choice a. (The core temperature should be much higher than the surface temperature.)
69 Choice e. (standard candle.)
70 Choice c. (A simulation, using currently accepted physical laws, of waves crashing on the beach.)
71 Choice d. (carbon dioxide.)
72 Choice e. (generates a neutrino burst.)
73 Choice c. (2 parsecs.)
74 Choice e. (-350°F)
75 Choice a. (electrical repulsion.)
76 Choice a. (avoid getting a false positive result.)
77 Choice a. (greater than 90 degrees.)
78 Choice a. (6 hours.)
79 Choice d. (Saturn)
80 Choice a. (Carbon Dioxide)
81 Choice e. (two regions of maximum pressure.)
82 Choice c. (only a few degrees so seasons are negligible.)
83 Choice c. (smoke and dust: It blocks the sunlight.)
84 Choice e. (the change in the object’s speed divided by the time it takes.)
85 Choice a. (Galileo’s theory was not disproven because the slight differences can be explained by defects in the experiment.)
86 Choice b. (flows like a liquid under gradual pressure but is stiff like a solid under sudden pressure.)
87 Choice e. (1%.)
88 Choice c. (larger than Mars.)
89 Choice c. (The Great Red Spot.)
90 Choice d. (North Celestial Pole.)
91 Choice d. (the same.)
92 Choice a. (100,000 parsecs.)
93 Choice b. (1200 m/s)
94 Choice b. (toward the Sun.)
95 Choice e. (icy objects condensed out just beyond Neptune.)
96 Choice b. (5000kg/m³)
97 Choice b. (Surveyor 1 in 1966.)
98 Choice b. (two sugar phosphate chains connected by pairs of nitrogenous bases.)
99 Choice e. (Atlantic Ocean.)
100 Choice a. (no magnetic field at all because it rotates so slowly.)
101 Choice e. (0.005m/s².)
102 Choice c. (a circular ring wall surrounding a flat area.)
103 Choice b. (Each DNA molecules splits in half and each half acts as a pattern to complete its other half.)
104 Choice c. (once every sidereal month.)
105 Choice d. (an atmosphere of Hydrogen and Helium with no real surface.)
106 Choice c. (Mariner 9)
107 Choice d. (+1.0)
108 Choice d. (Cygnus X-1.)
109 Choice b. (0.04 light years.)
110 Choice a. (Mars and Jupiter.)
111 Choice d. (Titan.)
112 Choice c. (100 parsecs.)
113 Choice a. (the planet Mars.)
114 Choice c. (the exhaustion of helium at its core.)
115 Choice b. (red, blue, and violet light.)
116 Choice e. (of the Planet Neptune.)
117 Choice b. (The Earth takes more time to go around the Sun and also moves slower than Mercury.)
118 Choice a. (K2 star of absolute magnitude 10.)
119 Choice a. (Cassegrain Focus.)
120 Choice e. (the Earth passes through comet debris.)
Where to find these questions in the lecture notes

1  Module 001.104-g01 The Sky: As Certain as the Sunrise. Observation.
2  **Module 007.602 Science Model Building Phases of Venus (34%)**
3  ***Module 024.504 The Hertzsprung-Russel Diagram, Spectroscopic Parallax (27%)***
4  Module 004.101-g01 The Sky: Wandering Planets Retrograde motion
5  Module 011.504 The Terrestrial Planets Mars Surface (50%)
6  Module 008.602 Science Models of Motion Action and Reaction (46%)
7  Module 020.402-g01 Stellar Parallax and Distance Parallax Angle and Distance
8  Module 021.202-g01 Using the Doppler Shift The Doppler Shift
9  Module 023.203-g01 Star Colors and Classes, Spectral Types
10 Module 011.305 The Terrestrial Planets Earth Orbit and Rotation
11 Module 028.105 Collapsed Objects, The Pulsar in the Crab Nebula 050.23
12 Module 014.103 Formation of the Solar System The Solar Nebula (F20113:74%)
13 ***Module 005.603-g01 The Sky: Power of Observation Kepler’s 2nd and 3rd Laws (22%)**
14 Module 007.503-g01 Science Model Building Phases of the Moon
15 Module 020.301-g02 Stellar Parallax and Distance What Causes Parallax?
16 Module 016.504 Earth’s Living Surface Comparing Earth to Other Planets
17 Module 013.305-g01 Comets and the Outer Solar System The Origin of Comets
18 Module 025.504 Stars of Extreme Mass (047.44)
19 Module 014.404-g01 Formation of the Solar System Jupiter Loses the Race
20 Module 016.402 Earth’s Living Surface Closing the Carbon Cycle
21 ***Module 011.301-g01 The Terrestrial Planets Earth Surface (20%)***
22 Module 026.405-g01 The Quiet Deaths of Ordinary Stars, Game Over: Everybody leaves 048.51
23 Module 024.502-g01 The Hertzsprung-Russel Diagram, Spectroscopic Parallax
24 *Module 012.212 The Jovian Planets Saturn Magnetic Field (39%)
25 Module 025.202 Mass and Energy (042.22)
26 **Module 029.202 The Milky Way Galaxy, How we Measure Distances Within It (052.32) (29%)**
27 Module 011.206-g01 The Terrestrial Planets Venus Orbit and Rotation
28 EModule 017.406 Earth Impacts Hunting Killer Asteroids RA1
29 **Module 003.302 The Sky: Celestial Sphere Star Motions (33%)**
30 *Module 014.403-g01 Formation of the Solar System Jupiter Loses the Race (35%)
31 Module 025.402-g01 Evolution onto the Main Sequence (047.32)
32 EModule 001.201-g01 The Sky: As Certain as the Sunrise. Honesty. Reproducible CT1
33 Module 008.503 Science Models of Motion Force and Mass
34 Module 002.402 The Sky: Spherical Earth. Circumference
35 Module 012.317-g01 The Jovian Planets Uranus Space Probes
36 ***Module 020.301 Stellar Parallax and Distance What Causes Parallax? (24%)***
Module 029.301 The Milky Way Galaxy, Where are We in it? (052.41)

Module 001.103-g01 The Sky: As Certain as the Sunrise. Observation (36%)

Module 009.606-g01 Science Models of Gravity Artificial Satellites

Module 029.101 The Milky Way Galaxy, How We See it (052.11)

Module 007.402-g01 Science Model Building Time and Compass Heading

*Module 013.303 Comets and the Outer Solar System The Origin of Comets (37%)

Module 019.413 The Search for Life Extrasolar Planets

Module 020.407-g01 Stellar Parallax and Distance Parallax Angle and Distance

Module 007.602-rev Science Model Building Phases of Venus (?)

Module 024.101B The Hertzsprung-Russell Diagram, A dot for each star

Module 019.502 The Search for Life SETI: Search for ExtraTerrestrial Intelligence

Module 019.306 The Search for Life The Jovian Moons

Module 029.406 The Milky Way Galaxy, What is its Overall Shape? (053.23) (46%)

Module 001.503 The Sky: As Certain as the Sunrise. Flat Earth Model

Module 006.402-g01 Science Scientific Statements The Scientific Fact Problem

Module 019.401-g01 The Search for Life Extrasolar Planets

Module 022.304-g01 Stellar Magnitudes and Distance Luminosity, Apparent and Absolute Magnitudes

EModule 006.104-g01 Science Scientific Statements How to test a statement CT2

Module 017.105 Earth Impacts Near Earth Objects

Module 012.119 The Jovian Planets Jupiter Moons

Module 011.214 The Terrestrial Planets Venus Space Probes (42%)

Module 011.204-g01 The Terrestrial Planets Venus Surface

Module 008.507 Science Models of Motion Force and Mass F=ma

EModule 015.402 Earth’s Atmosphere and Interior Greenhouse Effect EC5

Module 005.401 The Sky: Power of Observation Kepler’s War with Mars

Module 010.101-g01 Solar System Overview The Big Picture

Module 018.203 Requirements for Life The Chemical Basis of Life

Module 010.304-g01 Solar System Overview The Jovian Planets

Module 007.510 Science Model Building Phases of the Moon

Module 003.601 The Sky: Celestial Sphere. The Seasons

Module 025.108-g01 The Building Blocks of Matter (042.18) (41%)

Module 016.103-g01 Earth’s Living Surface An Active Crust

Module 022.502 Stellar Magnitudes and Distance Luminosity, Preview of the Distance Ladder

Module 007.102 Science Model Building Scientific Models

Module 018.309 Requirements for Life The Requirements for a Carbon Cycle

Module 027.302 Supernova Explosions, Neutron Matter 049.42

EModule 020.405-g01 Stellar Parallax and Distance Parallax Angle and Distance QR2
Module 012.304 The Jovian Planets Uranus Surface
Module 025.303 Ignition (042.33)
Module 019.208 The Search for Life Mars
**Module 007.304-g01 Science Model Building the Sun (33%)**
Module 003.306-g01 The Sky: Celestial Sphere Star Motions
Module 012.222 The Jovian Planets Saturn Space Probes
Module 015.101 Earth’s Atmosphere and Interior A Thin Layer of Air
Module 021.102 Using the Doppler Shift Describing Waves
Module 012.110-g02 The Jovian Planets Jupiter Orbit and Rotation (42%)
**Module 017.303 Earth Impacts Large Object Impacts EC4**
Module 008.301-g01 Science Models of Motion Acceleration
Module 008.404-g01 Science Models of Motion The Universality of Free Fall
Module 015.503-g01 Earth’s Atmosphere and Interior The Earth’s Interior
*Module 015.102-g01 Earth’s Atmosphere and Interior A Thin Layer of Air(35%)
***Module 018.313-g01 Requirements for Life The Requirements for a Carbon Cycle (22%)
Module 012.106 The Jovian Planets Jupiter Surface
Module 003.205 The Sky: Celestial Sphere Pointer Stars
Module 018.114-g01 Requirements for Life Light
Module 022.403 Stellar Magnitudes and Distance Luminosity, Finding the distance
Module 021.110 Using the Doppler Shift Describing Waves
Module 009.101 Science Models of Gravity Explaining Kepler’s Laws
Module 014.506 Formation of the Solar System The Fates of Dirty Snowballs
Module 010.201 Solar System Overview The Terrestrial Planets
Module 011.421 The Terrestrial Planets Moon Space Probes
Module 011.406-g01 The Terrestrial Planets Moon Surface Features (32%)
**Module 011.408 The Terrestrial Planets Moon Orbit and Rotation (42%)**
EModule 011.107-g01 The Terrestrial Planets Mercury Magnetic Field (38%)
EModule 008.518-g01 Science Models of Motion Force and Mass a = F/m QR1
**Module 011.406-g01 The Terrestrial Planets Moon Surface Features (32%)**
EModule 018.503 Requirements for Life Reproduction (F20113:86%,86%) EC3
Module 011.408 The Terrestrial Planets Moon Orbit and Rotation
Module 012.201 The Jovian Planets Saturn Surface
*Module 011.517 The Terrestrial Planets Mars Space Probes (40%)
Module 022.201-g02 Stellar Magnitudes and Distance Luminosity, The Magnitude Scale
Module 028.403 Collapsed Objects, Detecting Black Holes 051.23
*Module 029.502 The Milky Way Galaxy, The Monster in the Core (055.12) (38%)
Module 010.404-g01 Solar System Overview Asteroids
*Module 019.302 The Search for Life The Jovian Moons (37%)
*Module 022.402 Stellar Magnitudes and Distance Luminosity, Finding the distance (38%)
Module 011.520 The Terrestrial Planets Mars Space Probes
Module 026.301 The Quiet Deaths of Ordinary Stars, The Red Supergiant Stage 048.31 (43%)
Module 018.404-g01 Requirements for Life The Energy Sources of Life
Module 009.504-g01 Science Models of Gravity Making New Predictions
Module 005.604-g01 The Sky: Power of Observation Kepler’s 2nd and 3rd Laws
EModule 024.103-g02 The Hertzsprung-Russell Diagram, A dot for each star QR3
Module 020.202 Stellar Parallax and Distance Telescopes
Module 013.203 Comets and the Outer Solar System Meteor Showers