Exam 01: Chapters 00–02

The very bright bluish star **Spica** (αVir) is located in the constellation Virgo. Tonight (07/13/16) at 10:00 PM, Spica will have an azimuth **AZ = 230°** and altitude **ALT = 28°**, as viewed from here in Conway. The right ascension of Spica is **RA = 13h 25m 11.5s**, and the declination is **DE = –11°09'41"**. Answer Questions 1–4 below using this information.

1. A second star, **Zavijava** (βVir), is also located in the constellation Virgo. How are these stars related?
   A) All of the stars in any specific constellation are part of a related cluster. That's why they appear in patterns: because they are actually located close to one another.
   B) The patterns have no genuine astronomical significance, because the stars in a constellation are unrelated to each other. They may have cultural significance to the people viewing them, however.
   C) The constellations are significant because of the gravitational effect they have on every person. Where those constellations are at your moment of birth determines your personality traits and your fate.
   D) We need to know the pattern of the constellations of the zodiac, because until we find the planet with those particular patterns in the night sky, we will never find the fabled thirteenth colony—Earth!

2. What does the **right ascension** of Spica signify?
   A) Spica always rises 13h 25m 11.5s after the Sun rises.
   B) Spica always rises 13h 25m 11.5s after the Sun sets!
   C) Spica is visible in the sky above the horizon for exactly 13h 25m 11.5s each night.
   D) None of these is correct; right ascension is not a measurement of *time*, but a coordinate of *position*.

3. What does the **declination** of Spica tell you about its location in the night sky? Spica will be found
   A) 11°09'41" east of the vernal equinox.
   B) 11°09'41" north of the celestial equator.
   C) 11°09'41" south of the celestial equator.
   D) 11°09'41" above the horizon as viewed from Conway.

4. If you go out 6 months from now at 10:00PM and view the sky,
   A) you will see precisely the same set of constellations in precisely the same locations.
   B) you will see a different array of constellations.
   C) you will not see any constellations, because stars are only visible in the summer.
   D) you cannot predict what will or won't be visible.

5. Your friend at the Benmore Peak Observatory in New Zealand just texted you the coordinates of the bright star Rigil Kent. It has **RA = 14h39m31.4s** and **DE = –60°49'13"**. If you are here in Conway (35°N latitude), can you observe this star? Yes or **no**?

6. Which of the following observations can be interpreted as evidence that the Earth is **spinning on its axis**?
   A) The Moon does not eclipse the Sun every month.
   B) The Moon passes through a cycle of phases each month.
   C) If you watch the stars over the span of an evening, they seem to move in a circle about the pole star, Polaris.
   D) The constellations visible to you at night change over time. Virgo, for example, is visible in the summer sky but not during the winter.

7. Which of the following observations can be interpreted as the Earth's motion as it **orbits the sun**?
   A) The Moon does not eclipse the Sun every month.
   B) The Moon passes through a cycle of phases each month.
   C) If you watch the stars over the span of an evening, they seem to move in a circle about the pole star, Polaris.
   D) The constellations visible to you at night change over time. Virgo, for example, is visible in the summer sky but not during the winter.

8. Compare a **solar** and **sidereal** day.
   A) Both solar and sidereal days are precisely 24 hours in length. There is no difference.
   B) A solar day is how long it takes the Sun to rotate once on its axis. A sidereal day is how long it takes a random star to rotate once on its axis.
   C) A solar day measures the rotation of the Earth with respect to the Sun. A sidereal day measures the Earth's rotation with respect to an arbitrary star.
   D) A solar day is how long it takes the Earth to complete one rotation on its axis. A sidereal day is how long it takes the Earth to complete one revolution around the sun.

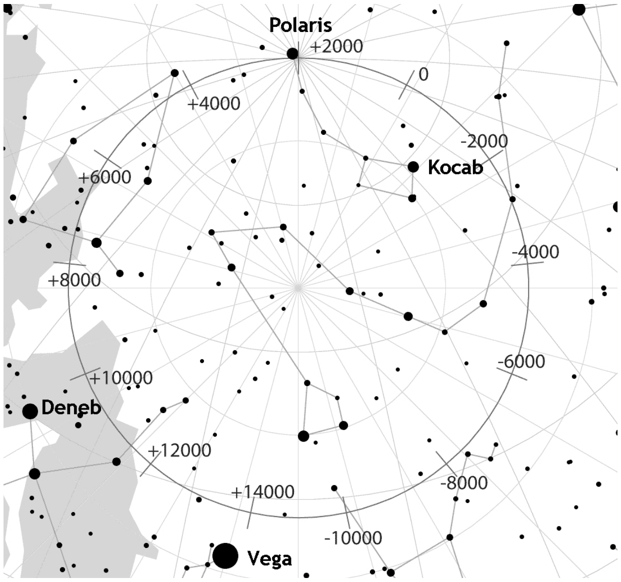
9. Compare the orientation of the **ecliptic** to the **celestial equator** (CE).
   A) The ecliptic is perpendicular to the CE.
   B) The ecliptic coincides with the CE; they are the same.
   C) It varies. They are the same on the equinoxes, but 90° apart on the solstices.
   D) The ecliptic is angled at 23.5° to the CE, because of the tilt of the Earth's axis.

10. What is the **declination** of the Sun on the day of the **summer solstice** (06/21)?
   A) –90°. C) 0°. E) +90°.
   B) –23.5°. D) +23.5°. F) Depends on location!

11. What is the **altitude** of the Sun at noon on the day of the **summer solstice** (06/21)?
   A) 90°. The Sun is always directly overhead at noon.
   B) 23.5°, the same as the tilt of the Earth's axis.
   C) 0°. The Sun is always just on the horizon at noon.
   D) Trick question! The *altitude* of the Sun at noon depends on your *location*.

12. On the day of the **winter solstice** (12/21), compare the day in Barrow, Alaska (**71°N latitude**) with that at McMurdo Station, Antarctica (**77°S latitude**).
   A) The sun will not rise in Barrow (24 hours of darkness), and it will not set in McMurdo (24 hours of daylight).
   B) Barrow will have 24 hours of daylight, while McMurdo will have 24 hours of darkness.
   C) Both locations will be in darkness. At any latitude above 66° (N or S), the sun never rises.
   D) Both locations will be in daylight. At any latitude above 66° (N or S), the sun never sets.

Use the figure below to answer Questions 13 and 14.



13. What is the "wobble" of the Earth's axis (shown above)?
    A) Recession.
    B) Precession.
    C) Declination.
    D) Aberration.

14. Six thousand years from now (+8000), none of us will be here. But when whoever *is* here looks at the sky, they will see
    A) the stars appear to circle Polaris.
    B) the stars appear to circle Vega.
    C) the stars appear to circle Deneb.
    D) the stars appear to move, but there will be no Pole Star which appears stationary.

15. True or false: The first quarter Moon will appear highest in the sky at about midnight.

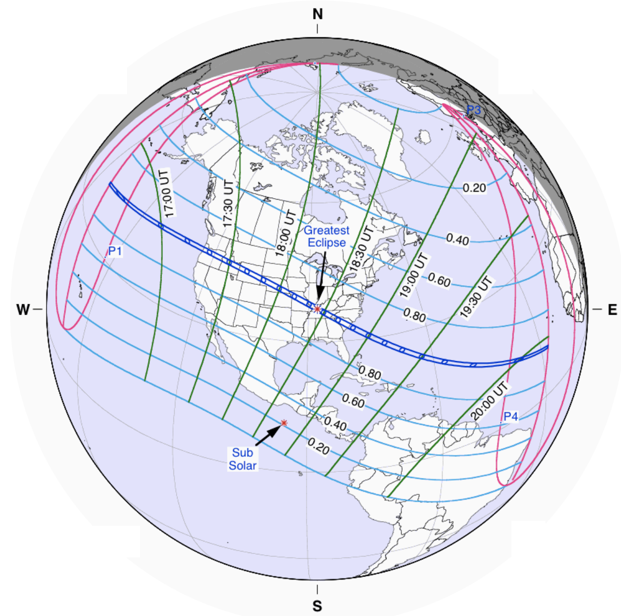
16. Next Monday (07/18/16), the Moon will be full. At *about* what time will the Moon rise?
    A) About noon.
    B) About sunset.
    C) About midnight.
    D) About sunrise.
    E) Trick question! It will not rise at all.

17. A **solar eclipse** occurs when
    A) the Sun blocks the light from the Moon.
    B) the Moon appears to cover the disk of the Sun.
    C) the Earth casts its shadow on the Moon.
    D) Mercury or Venus pass in front of the Sun, blocking its light.

18. A **lunar eclipse** occurs when
    A) the Sun blocks the light from the Moon.
    B) the Moon appears to cover the disk of the Sun.
    C) the Earth casts its shadow on the Moon.
    D) Mercury or Venus pass in front of the Moon, blocking its light.

19. On September 01, 2016 there will be a solar eclipse. True or false: You would expect to view a lunar eclipse about two weeks later, on September 16, 2016.

20. The predicted path of the solar eclipse of August 21, 2017 is shown below. True or false: Arkansas is well within the band of totality, and we will see a total eclipse pretty much everywhere in the state.



21. Will anyone in Australia be able to view this eclipse? Yes or no?

22. When you hold your thumb out in front of you, viewing it first through your right eye, then through your left, you are illustrating the concept of **parallax**. As you do this,
    A) your thumb appears stationary against the shifting background behind it.
    B) your thumb appears to move against a stationary background as you switch from one eye to the other.
    C) Both your thumb and the more distant background appear to shift. Confusing and mystifying!
    D) both your thumb and the background appear fixed, regardless of which eye you use. Silly and pointless!

23. If you now move your thumb closer to your eyes, and repeat (viewing it first through your right eye, then through your left), what happens to the parallax?
    A) Nothing. Nothing happened the first time, so why would anything happen now?
    B) Your thumb appears to shift less against the background when it is closer to you. Smaller parallax!
    C) Your thumb appears to shift more against the background when it is closer to you. Greater parallax!
    D) It does not matter how close or how distant your thumb is (compared to the more distant background). Same parallax!

24. The star **Wolf 1061** has a parallax of **2.34 arcsec**, while the star **Ross 652** has a parallax of **1.70 arcsec**. What can you correctly conclude?
    A) Nothing at all. Parallax is an optical illusion, so it can't really tell you anything about a star.
    B) Ross 652 is brighter than Wolf 1061.
    C) Ross 652 is hotter than Wolf 1061.
    D) Ross 652 is farther from Earth than Wolf 1061.

25. Compare the units of astronomical distances: **parsec** (pc), **astronomical unit** (AU), and **light year** (ly).
    A) In order of increasing size, the units are: pc, AU, ly.
    B) An AU is the smallest unit, and the pc is the largest.
    C) It is customary to use AU to measure distances in our own galaxy, but pc to measure distances in other galaxies. Sort of like how we use miles here in the US, but we would use kilometers in Europe.
    D) Trick question! Parsecs and light years are not actually units of *distance* at all, they are units of *time*. The AU is the only distance unit listed.

26. Why do we call it "Einstein's *Theory* of Relativity?"
    - A) Because it has been tested repeatedly for over a hundred years, and never shown to be false.
    - B) Because it's only a theory, and like all theories, nobody can really say if it's right or wrong.
    - C) Because Einstein was brilliant, and almost everything he said is automatically true.
    - D) Because it's an untested idea. Once someone figures out a way to test it, it can become an hypothesis (if it holds up to experiment).

27. How many planets can be seen with the unaided eye?
    - A) All of them, including dwarf planets like Pluto.
    - B) None of them. You need at least a pair of binoculars to see any of the planets.
    - C) Most of them. Only the most distant planets (Uranus and Neptune) require binoculars or a telescope to be observed.

28. True or false: When looking for planets in the night sky, you should look close to the ecliptic.

29. Planets moving **prograde** appear to move across the sky
    - A) from north to south.
    - B) from south to north.
    - C) from east to west.
    - D) from west to east.

30. What is the best explanation for **retrograde** motion?
    - A) Aliens.
    - B) Retrograde motion is naturally observed as a planet moves around its epicycle and along its deferent as it orbits the Earth.
    - C) Retrograde motion is the result of a planet stopping its forward motion, reversing direction, traveling backwards along its orbit, then resuming its forward progress.
    - D) As the Earth overtakes and passes a planet traveling around the Sun, it appears to us as if that planet slows, then moves in reverse for a brief time. The planet does not actually reverse its motion.

31. Aristotle argued that the Earth was stationary because
    - A) it is. The Earth is a motionless flat plane at the center of the universe.
    - B) he wasn't very smart. It has always been obvious that the Earth is a spinning sphere hurtling through space.
    - C) he could not observe stellar parallax. He was correct that it should exist, but it was another 2000 years before a telescope powerful enough to observe it was built.
    - D) he noticed that some planets occasionally reversed their direction of travel, while the Earth never did.

32. If Ptolemy's geocentric model was correct, what would the planet Venus look like to an observer on Earth?
    - A) Venus would always appear as a crescent, with most of its disk not visible.
    - B) Venus would always appear as a complete disk, like the full moon (only it would appear smaller).
    - C) Venus would appear to go through a cycle of phases similar to the moon, waxing and waning. Sometimes a crescent, sometimes a full disk.

33. Galileo began using a telescope in 1609. Which of the following was **not** one of his astronomical observations?
    - A) By mapping sunspots, he demonstrated that the sun was rotating on its axis, just like the Earth.
    - B) He observed and sketched the craters and maria of the moon, showing that it was not a perfect orb.
    - C) He showed that Jupiter had four moons orbiting it, proving that not everything orbited the Earth itself.
    - D) He was amazingly lucky to see a supernova explode, but he did not understand what he was observing.

34. How did Kepler come up with elliptical orbits?
    - A) He didn't. That was Copernicus, who was the first person to suggest that planets orbited the Sun rather than the Earth.
    - B) He was well acquainted with Galileo, and was able to use the observations that Galileo made with his new telescope to prove that planetary orbits were ellipses.
    - C) He had an enormous quantity of very precise data inherited from Tycho Brahe. By painstakingly plotting planetary orbits, he was able to demonstrate that they were not circular.
    - D) He read about Newton's Law of Universal Gravitation, and realized that the planets must obey the same law. After that, it was just a straightforward math problem.

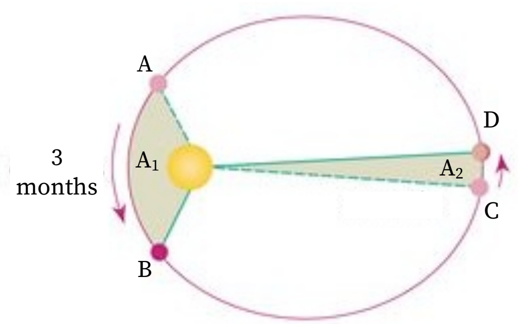
35. If the orbit of a hypothetical planet has an eccentricity $e = 0.02$, what does the orbit look like?
    - A) Eccentricity $e = 0.02$ is a perfect circle.
    - B) Eccentricity $e = 0.02$ is not a perfect circle, but just a little bit elongated on its major axis.
    - C) Eccentricity $e = 0.02$ is a *very* elongated ellipse.
    - D) Eccentricity $e = 0.02$ is actually a straight line!

On 11/22/2015, the planet Mars was 1.67 AU from the Sun. On 10/26/2016 Mars will be only 1.41 AU from the Sun. Use this information to answer questions 36–38.

36. According to **Kepler's First Law**, the orbit of Mars is an ellipse with the sun at one focus. What is located at the *other* focus?
    - A) Nothing.
    - B) The Earth.
    - C) Another sun.
    - D) A black hole.
    - E) The Restaurant at the End of the Universe.

37. On which day will Mars be *closest* to **aphelion**?
    - A) 11/22/15
    - B) Neither. Aphelion would be halfway between those dates, or about the end of May, 2015.
    - C) 10/26/16

38. According to **Kepler's Second Law**, on which date was Mars traveling **faster** along its orbit?
    - A) 11/22/15
    - B) Neither! It always travels at exactly the same speed.
    - C) 10/26/16



39. **Kepler's Second Law of Planetary Motion** is shown in the figure above. If the shaded area A_1 is exactly equal to the area A_2, how long does it take for the planet to travel from point **C** to point **D** on its orbit?
    - A) Three months.
    - B) Six months.
    - C) Nine months.
    - D) Trick question! There is no way to know for sure how long it will take!

40. According to **Kepler's Third Law**, the period of a planet's orbit
    - A) is directly proportional to its distance from the sun: a planet at 1AU takes 1 year to orbit, a planet at 2AU requires 2 years, etc.
    - B) is inversely proportional to its distance: at double the distance (2AU), a planet requires only half the time (0.5 year) to complete an orbit.
    - C) increases with distance, but the relationship is not linear, it is a power law.
    - D) is impossible to predict. The only way to figure out the period is by direct observation over a long period of time.

41. Use **Kepler's Third Law** to predict the orbital period in years of a hypothetical planet located at a distance **5 AU** from the Sun. (Think for a minute before you grab your calculator!) The orbital period is *closest* to
    - A) 1 year
    - B) 2.23 years
    - C) 5 years
    - D) 11 years
    - E) 25 years
    - F) 125 years

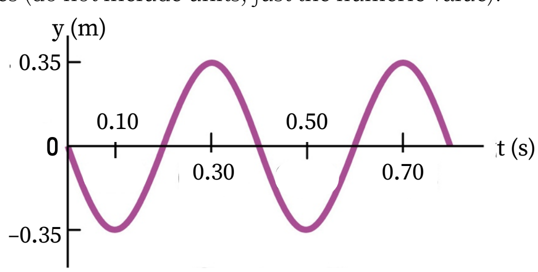
Two masses, m_1 and m_2, are separated by a distance r. The gravitational force between them is measured to be 12N. Answer Questions 42 and 43 below using this information.

42. If the masses are moved so that the separation between them is decreased from 2m to 1m, what is the new gravitational force on m_1 due to m_2?
    - A) 3 N
    - B) 6 N
    - C) 12 N
    - D) 24 N
    - E) 48 N
    - F) 96 N

43. At the original separation, the force is again 12N. What would happen if you replaced m_1 with a smaller mass?
    - A) Nothing. Changing the mass does not affect the force, only the distance affects the force.
    - B) Smaller mass, smaller force. Half the mass will decrease the force from 12N to 6N.
    - C) Smaller mass, smaller force, but the relationship is not linear: half the mass, ¼ of the force!
    - D) Smaller mass, larger force: half the mass will result in twice as much force, 24N instead of 12N.

44. Neptune has an average distance of **30 AU** from the sun, while the Earth is at **1 AU**. When the Voyager 2 spacecraft (launched form Earth) reached Neptune in 1989, how much gravitational pull from the sun did it experience?
    - A) The force due to the sun on the probe will be $1/(30)^2$, or only 1/900 the force felt at 1AU.
    - B) The force of gravity on this spacecraft would only be 1/30, or about 3%, of the force exerted at 1AU.
    - C) The space probe would experience precisely the same force at 30AU as it did at 1AU.
    - D) This probe would experience a force on it 30 times greater than the force at 1AU.
    - E) The force of gravity at 30AU would be an amazing 900 times greater than the force at 1AU!

Answer Questions 45–47 using the wave diagram below. Answer each question numerically with exactly two decimal places (do not include units, just the numeric value).



45. What is the **amplitude** of this wave? $A = 0.35$m

46. What is the **period** of this wave? $T = 0.40$s

47. What is the **frequency** of this wave? $f = 2.50$ Hz

48. If the wave above has a **wavelength λ = 1m**, what is its **speed**?
    - A) 0.35 m/s
    - B) 0.40 m/s
    - C) 0.50 m/s
    - D) 1.5 m/s
    - E) 2.5 m/s
    - F) 2.9 m/s

49. A sound wave with wavelength **λ = 1m** travels through the air, across the room, and approaches an open doorway (also about 1m wide). As it passes through the open door,
    - A) the wave diffracts significantly. The wavefront bends as the wave passes through the aperture.
    - B) there is virtually no diffraction. The wavefront passes through the aperture without bending at all.
    - C) the wave stops; it actually *cannot* pass through the open door. Remind me what the point of this question is...

50. True or false: A larger aperture (wider door) increases the amount of diffraction the sound wave experiences.

51. Compare the wavelength of **visible light** to **gamma rays**.
    - A) The visible portion of the e·m spectrum has longer wavelength and lower frequency.
    - B) The gamma portion of the e·m spectrum has longer wavelength and lower frequency.
    - C) It depends on the energy. If the visible light has more energy, it has a longer wavelength. But if the gamma rays are more energetic, they have the longer wavelength.
    - D) Trick question! All portions of the e·m spectrum have the same constant wavelength.

52. If you oscillate an electron slowly (with a **low frequency**), you will generate a radio wave. What happens if you oscillate the same electron with a **greater frequency**?
    - A) There is no change. The oscillating electron still produces a radio wave having the same wavelength, frequency, and speed.
    - B) Increasing the frequency decreases both the wavelength and speed: shorter λ, slower v.
    - C) Increasing the frequency decreases the wavelength, but the e·m wave will still have the same speed.
    - D) Increasing the frequency increases both the wavelength and the speed: longer λ, faster v.

53. The Sun emits low frequency radio waves and high frequency x-rays as well as visible light.
    - A) The radio waves travel the slowest through space, the x-rays travel the fastest.
    - B) X-rays are the slowest, radio waves are the fastest.
    - C) Visible light travels through space faster than either the radio or x-rays.
    - D) All forms of electromagnetic radiation travel at the same speed through space.
    - E) Trick question! Electromagnetic radiation cannot travel through the vacuum of space.

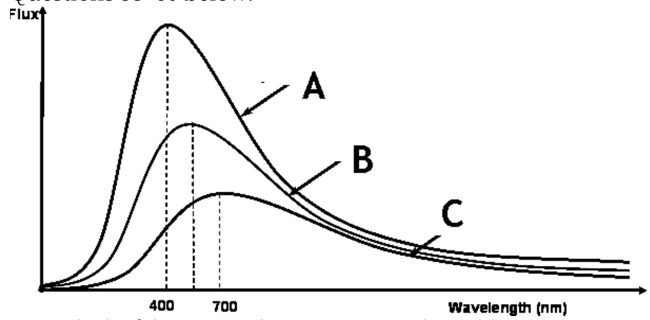
54. Which of the following phenomena **could not be observed** using a ground-based telescope?
    - A) The gamma ray burst of a supernova (violently exploding star).
    - B) The difference in color between a blue and a red star.
    - C) Radio waves emitted by a lightning storm on Venus.
    - D) Absorption lines in the visible portion of the sun's e·m spectrum.
    - E) Trick question! You could not observe *any* of these things using a ground-based telescope.

55. Human eyes are sensitive to visible light. Why *aren't* our eyes sensitive to x-rays or gamma rays?
    A) Because x-rays are unrelated to visible light.
    B) Humans see visible light because it penetrates the atmosphere. We did not evolve x-ray vision because x-rays do not penetrate Earth's atmosphere.
    C) Because x-rays are dangerous, and (most) cavemen knew this. Any caveman with naturally occurring x-ray vision would have been killed when he left his cave to go outside and look at the x-rays. Thus, only the cavemen without x-ray vision who stayed safe in their caves survived to reproduce.

56. True or false: The coldest temperature ever recorded (either on Earth or out in space) was –273K.

57. Why are some astronomical images labeled "false color?"
    A) They are artistic representations, where a person just chose colors they liked to tint an image.
    B) They are showing wavelengths of light that human eyes cannot see. Wavelengths we can't see are mapped onto a range of colors we can see.
    C) Astronomical objects literally have no color. Stars, planets, and nebulae all appear exactly the same, so a false color is applied to tell the difference (yellow = star, red = planet, blue = nebula).
    D) Astronomical images are always negatives; the actual objects will have the opposite color shown in the image.

The blackbody curves for three separate stars are shown below. Use the multiple choices on the figure to answer Questions 58–60 below.



58. Which of the curves above represents the **reddest** star? C
    D) Stars A, B, an C are all red stars.
    E) None of the stars shown are red stars.

59. Which of the curves represents the most **sun-like** star? B
    D) Stars A, B, an C are all sun-like stars.
    E) None of the stars shown are sun-like stars.

60. Star B above shows a peak wavelength at 550 nm, or **5.5×10^{-5}cm**. According to **Wien's Law**, the approximate temperature of this star is *closest* to
    A) 0 K
    B) 3300 K
    C) 4300 K
    D) 5300 K
    E) 6300 K
    F) 7300 K