Enter your answers on the form provided. Be sure to write your name and student ID number on the first blank at the bottom of the form. Please mark the version (A) in the “Key ID” space at the top of the Scantron. If you need to erase an answer, please do so carefully and remove all of the old mark.

1. If you know the energy of a photon, you can compute
   a. its position  b. its frequency  c. its size
   d. its frequency and wavelength
   e. its speed

2. Two stars are identical in all respects but one: Star B is three times further away from us than Star A. What are the relative brightnesses of these two stars?
   a. Star A is three times fainter than Star B
   b. Star B is three times fainter than Star A
   c. Star A is nine times fainter than Star B
   d. Star B is nine times fainter than Star A
   e. The stars appear equally bright

3. Examine the figure below. When was it taken?
   a. at dawn  b. at dusk  c. either a.) or b.)  d. could have been any time at night
   e. close to midnight

4. $583 =$
   a. $5.83 \times 10^0$  b. $5.83 \times 10^2$  c. $5.83 \times 10^{-5}$  d. $5.83 \times 10^{-4}$  e. $5.83 \times 10^{-3}$

5. An ad claiming that a product is light-years ahead of its time does not make sense because
   a. a light-year is so large that a product could not possibly be so advanced.
   b. light-years only apply to light.
   c. it doesn’t say the number of light-years.
   d. it uses light-years to talk about time, but a light-year is a unit of distance.
   e. it gives no comparison with similar products
6. Two identical planets are orbiting two identical stars very similar to the Sun. The one planet has a mass and orbital radius identical to the Earth’s. The other planet is in a similar orbit but is two times more massive. How different is the force of gravity on this second planet than on the Earth-like planet?
   a. the force is about 2 times weaker  
   b. the force is about 9 times weaker  
   c. the force is about 4 times weaker  
   d. the force is the same  
   e. the force is 2 times stronger

7. You obtain spectra of two stars you think are identical (see below). One is nearby (the upper one, labeled “unshifted”). What is most likely to be different about the second star (lower spectrum)?
   a. it is cooler, causing its spectrum to peak further into the red  
   b. the electric force is a bit weaker, shifting the electrons to different orbits in its gas  
   c. it has very high surface gravity that causes the photons to lose energy as they leave it  
   d. it is moving rapidly toward us  
   e. it is moving rapidly away from us

8. Galileo’s greatest contribution to science was
   a. he showed that science was superior to religion  
   b. he wrote his results up in books and had them published for general circulation  
   c. he built telescopes and made important observations with them  
   d. he did experiments  
   e. he proved that the Copernican system was correct

9. Copernicus’ theory for the solar system
   a. made much more accurate predictions than previous theories  
   b. was much simpler than previous theories  
   c. was obviously a big improvement over previous theories  
   d. introduced new physical principles to understand the motions of the planets  
   e. none of the above

10. The major contribution of the Greeks to astronomy was:
    a. To make more accurate measurements than the Babylonian astronomers  
    b. To observe consistently over long periods to discover patterns in the motions of the sun, moon, and planets  
    c. To make accurate predictions about the positions of the moon and planets  
    d. To get the attention of powerful rulers and other people for their work  
    e. To invent science

11. Einstein is not given credit for solving the problem of planetary motions because
    a. Newton came first, so he got credit even though his laws were not correct  
    b. Newton was a better scientist than Einstein  
    c. Newton’s laws provided an accurate explanation without Einstein’s additions  
    d. It’s just politics – Newton was English and Einstein was German  
    e. Einstein’s theories are still under test
12. If you are at the Equator and observe the sky for an entire year, you will be able to see
   a. just the circumpolar stars
   b. half the bright stars in the sky
   c. pretty much the same bright stars visible from any other single spot on Earth
   d. only the stars between the Tropics of Cancer and Capricorn
   e. virtually all the bright stars in the sky

13. Which controls accelerate a car, according to Newton's Laws?
   a. the accelerator
   b. the brake
   c. the clutch
   d. the steering wheel
   e. all but the clutch

14. At what temperature does an object emit electromagnetic radiation?
   a. at any temperature above absolute zero
   b. just at temperatures above freezing
   c. just around 5500° K, where visible light is emitted
   d. there is no real connection between temperature and emissions
   e. just above 0° C

15. Kepler's "music of the spheres" theory
   a. was an impressively good fit to the planetary orbital periods
   b. was an impressively good fit to the eccentricities of the orbits of the planets
   c. related the day to the month and year
   d. was a good start toward a physical theory for the motions of the planets
   e. was a good explanation for Tycho’s measurements of the motions of the planets but has been shown to be wrong
      by modern observations

16. People often refer to the side of the moon away from the earth as the "dark side". Is this term correct?
   a. Yes, that side hardly ever gets any light
   b. That side only gets lit by earth shine (reflected from the earth) and so it is not completely dark, but almost
   c. We can’t know for sure without sending a spacecraft there to make measurements
   d. Partly, since there is less light on that side than on the one toward the earth
   e. No, all sides of the moon get about the same amount of light

17. 5.4 X 10\(^{-3}\) equals
   a. -5.43
   b. 5400
   c. 5.1
   d. 0.0054
   e. none of the above

18. When Galileo found that Venus had phases, he could confidently argue that
   a. Venus orbits the earth, like the moon
   b. Tycho's model for the solar system was wrong
   c. Venus orbits the sun
   d. Venus comes between the earth and sun on its orbit
   e. Venus has a dark side that never gets illuminated
19. An asteroid is 3 AU from the sun. What does the graph indicate is the time for it to go around the sun?
   a. 1 year
   b. 11 years
   c. 5 years
   d. 3 years
   e. it cannot be determined

20. The relation between distance from the sun and time to go around an orbit in the graph is from
   a. Copernicus's solar system calculations
   b. Newton's law \( F = ma \)
   c. Galileo's 's first law
   d. the law of gravitation
   e. Kepler's third law

21. When the sun is highest in the sky at noon for us (in Tucson), what seasonal event is occurring in Santiago, Chile?
   a. summer solstice
   b. autumnal (fall) equinox
   c. winter solstice
   d. vernal (spring) equinox
   e. summer

22. Telescopes are put in space to:
   a. Get them closer to the stars
   b. Get where it is never cloudy
   c. Let astronomers observe day and night
   d. Avoid the absorption by the atmosphere
   e. To make them accessible to astronomers all over the world

23. Scientists
   a. use new theories to test old ones
   b. use observations to make predictions that can be tested by future theories
   c. do not accept observations that disagree with theory
   d. use observations to test their theories
   e. derive new theories without reference to observations

24. The most persuasive reason ancient astronomers thought the earth was fixed in space and did not orbit the sun was:
   a. the earth is different from bodies in space, which are just bright points of light
   b. space is unchanging while the earth changes all the time
   c. the directions toward the stars did not change over the year (there was no parallax)
   d. their gods placed the earth at the center of the solar system
   e. observations of eclipses of the moon showed that the earth stood still
25. An astronomer is designing a new telescope to use in space. The Hubble Space Telescope operates at wavelengths close to 500nm (1nm = 10^{-9} meter). The new telescope is to be used at 5000nm (in the infrared).
   a. such a telescope is not needed because nothing emits at 5000nm
   b. such a telescope will need to be 10 times larger in diameter to see the same level of detail
   c. such a telescope would be better built at sea level
   d. such a telescope should be a refractor
   e. such a telescope could be smaller than the Hubble Telescope to enable use of a cheaper rocket, while still returning pictures with similar detail

26. "anti matter"
   a. is repelled by gravitational fields
   b. is particles of opposite electric charge to every-day matter that annihilate with matter when the two encounter
   c. is predicted by some physical theories but has not been found
   d. is an invention of science fiction writers
   e. might be what Mars is made of

27. The seasons are primarily caused by
   a. the earth getting closer to and farther away from the sun as it goes around its elliptical orbit
   b. the fact that the axis of the earth is not perpendicular to the axis of its orbit around the sun
   c. changes in greenhouse effects
   d. increases and decreases in the energy produced by the sun
   e. large weather patterns

28. Aristarchus' ideas about the solar system
   a. were rejected because they made inaccurate predictions
   b. were rejected because they were wrong
   c. were rejected because he was judged not to be qualified
   d. were rejected because they did not come to the attention of other scientist/philosophers
   e. both c. and d.

29. Ideas in physics throughout the Greek and Medieval eras went astray because
   a. scientists could not do accurate calculations to test them
   b. of air resistance
   c. it was difficult to make predictions
   d. no one really thought much about physics
   e. none of the above

30. In the setup below, the observer will see
   a. a blackbody spectrum
   b. an emission line spectrum
   c. an absorption line spectrum
   d. a continuum spectrum
   e. it could be any of the four options above
31. The Maya developed astronomy
   a. to help their rulers make decisions, as a kind of elaborate astrology
   b. because they were pioneering true scientific thought
   c. because they needed something to apply their advanced number system to
   d. to educate the population in the methods of science
   e. so their astronomer/priests could live luxuriously in the monuments when they were not being used for astronomy

32. These days, astronomers usually use _______ for obtaining observations of visible photons from stars
   a. their eyes, looking through eyepieces on big telescopes
   b. refracting telescopes
   c. electronic detectors
   d. observing assistants
   e. photographic film

33. If the moon was full as viewed from the earth, but you were on the moon looking at the earth, what phase would the earth be in?
   a. new       b. first quarter       c. full       d. last quarter       e. gibbous

34. The most basic building blocks of matter that we know about are
   a. photons       b. antiprotons and antineutrons       c. quarks       d. neutrinos       e. protons, neutrons, and electrons

35. Galileo's dispute with the Church
   a. was purely a case of a hard-working scientist being persecuted for his views
   b. should never have occurred because Galileo had proof of all of his claims
   c. was primarily due to Galileo not giving credit to Jesuit priest scientists for their work
   d. reflected deep and fundamental philosophical differences about science and what it could do
   e. was trumped up by the Church with no provocation from Galileo

36. When we look at a star that is 30 million light years away, the light we see
   a. will be spread over the next 30 million years
   b. looks the same as it would have 30 million years ago
   c. was created 30 million years ago, before human-like beings existed on Earth
   d. is as it was 30 million light-years ago
   e. has dimmed by 30 million times in reaching us
37. Ancient civilizations that had a strong interest in astronomy
   a. were more advanced than any others
   b. developed sophisticated number systems and mathematics as part of their astronomy
   c. lived in desert areas where the sky was clear
   d. also developed excellent science in other areas
   e. had enlightened rulers who were interested in scientific discoveries

38. Wave-particle duality
   a. is a unique quality of light
   b. applies to matter but not anti-matter
   c. makes such strange predictions that scientists do not accept it
   d. applies to all fundamental particles
   e. is still under test to see if it is correct

39. When mass is annihilated
   a. It disappears into another universe
   b. passes into a black hole
   c. It is converted into energy, according to \( E = mc^2 \)
   d. It is converted into anti-mass
   e. It re-appears in the future

40. Galileo’s arguments for the Copernican system
   a. were based on solid proof that it was correct
   b. were well founded because his work improved the ability of this system to make accurate predictions
   c. were backed only by some good circumstantial evidence (phases of Venus, Galilean Satellites)
   d. built on the Greek work recorded by Aristotle
   e. were so obviously correct that anyone should have accepted them

41. An object that emits light with a peak wavelength at 1000nm has a temperature _____ that of an object whose emission peaks at 500nm. (1nm = 10^{-9} meters)
   a. the same as
   b. 5 times
   c. 2 times
   d. one half
   e. Cannot be computed from the information given.

42. Which of the following moves the fastest?
   a. visible light
   b. blue photons
   c. x-rays
   d. radio waves
   e. all move at the same speed

43. Observing in the radio, infrared, and X-ray
   a. has given astronomers new perspectives about celestial bodies
   b. has re-invigorated astronomy in the last 50 years
   c. has been tried but not found to be useful
   d. is the main impetus behind our building larger telescopes
   e. two of the above answers are correct

44. Astronomy played a big role in the early development of science in general because
   a. the motions of the moon and planets posed a precise, but difficult intellectual challenge
   b. astronomy was useful to predict when to take major steps, such as going to war
   c. astronomy was at the foundation of many important myths
   d. the sky was so awesome it inspired young scientists
   e. the best minds worked on astronomy

45. Newton’s explanation of Kepler's Laws is accepted as a full scientific theory because
   a. it was more easily understood than Kepler’s work
   b. it provided a more sophisticated version of Kepler's "music of the spheres"
   c. it used calculus and other sophisticated arguments
   d. it explained them in terms of simple laws that applied in many other situations also
   e. it cut the connections with religion and astrology
46. Kepler's great breakthrough in explaining the motions of the planets came because
   a. for the first time, he put the sun at the center of the system
   b. he developed a new understanding of the underlying causes for the relative sizes of the planet orbits
   c. he developed a theory for a force to keep the planets from slowing down
   d. he was the first to use mathematics to calculate planet orbits
   e. he fitted the planet orbits with ellipses, not combinations of circles

47. "Conservation of Energy" means that
   a. Laws should be passed to preserve energy for future generations
   b. Energy can be converted into matter and matter to energy according to $E=mc^2$
   c. An object in motion tends to retain the motion in the same direction and at the same speed.
   d. Energy must be supplied to conserve the motions of the planets in their orbits
   e. The sum of the energy associated with motion (kinetic) and that associated with the ability to do work (potential) stays the same in a system

48. Ptolemy's solar system model
   a. was not scientific
   b. used mathematical calculations to provide a reasonably good fit to the observations
   c. made no reference to observations - was just a theoretical construct
   d. was not quantitative - it just gave a general description of the planetary motions
   e. had obvious flaws that worried ancient astronomers and caused them to reject it

49. You can tell real science from pseudo-science because
   a. real scientists do not talk about pseudo-science
   b. pseudo-science is seldom modified as a result of making bad predictions or not reproducing observations
   c. real science is always correct
   d. only real science is discussed in newspaper stories and in news broadcasts
   e. pseudo-science is only practiced in underdeveloped countries

50. Progress in astronomy was particularly difficult during Medieval times because
   a. Kepler's advances were so great it was hard to improve on them
   b. Ptolemy's writings had been lost
   c. the differences between Ptolemy's theory and the motions of the planets were very small and hard to measure
   d. the Greek theories were particularly advanced on astronomy, making improvements difficult
   e. Aristotle's views were adopted widely and even codified as part of the Catholic religion