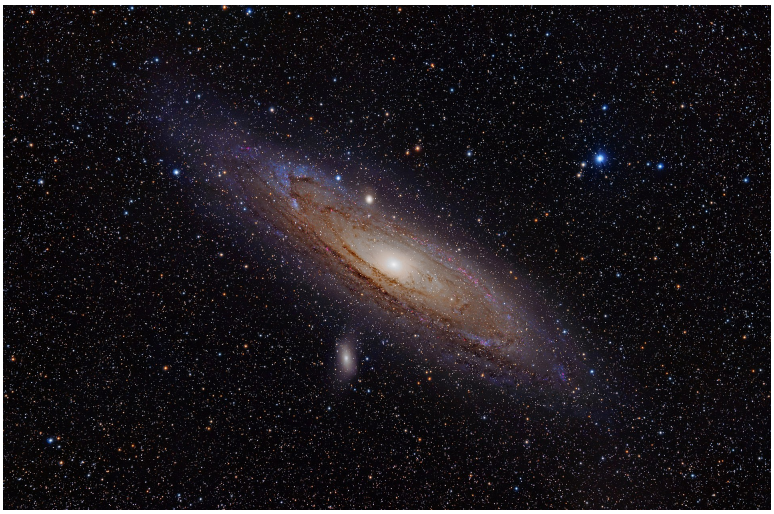
Science Olympiad
Reach for the Stars
UT Invitational

October 26, 2019
Austin, Texas



School: _____

Team Number: _____

Name(s): _____

Directions:

- Each team is allowed to bring in two 8.5" × 11" sheets of paper with information on both sides as notes, and two non-programmable, non-graphing calculators.
- Do not write on this test! It is a class set. Please write all answers on the answer sheets; any marks elsewhere will not be scored.
- There is no penalty for wrong answers. Answer every question, even if you aren't sure if you're correct.
- Above all else, just believe!

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Section:	A	B	C	Total
Points:	60	144	72	276
Score:				

Section A

Choose the correct answer to the following multiple choice questions to the best of your ability. Each question is worth 2 points for a total of 60 points.

1. Which of the following best describes the Sun?
    A. A moon
    B. A planet
    C. A star
    D. A galaxy
    E. A constellation

2. Which of the following best describes the Milky Way?
    A. A moon
    B. A planet
    C. A star
    D. A galaxy
    E. A constellation

3. Which of the following best describes Auriga?
    A. A moon
    B. A planet
    C. A star
    D. A galaxy
    E. A constellation

4. Which of the following lists the order of the main spectral types from hottest to coolest?
    A. OBAFGKM
    B. BOGAFMK
    C. ABFGKMO
    D. ABCDEFG

5. How do stars produce energy?
    A. Chemical reactions
    B. Nuclear reactions
    C. Electron degeneracy pressure
    D. Neutron degeneracy pressure
    E. None of the above

6. The spectral class of the Sun is:
    A. A
    B. G
    C. M
    D. O

7. When the Sun "dies", it will become a:
    A. Black hole
    B. White dwarf
    C. Supernova
    D. Red dwarf

8. On a typical H-R Diagram, _____ is on the x-axis, while _____ is on the y-axis.
    A. Temperature, pressure
    B. Temperature, luminosity
    C. Temperature, apparent magnitude
    D. Luminosity, apparent magnitude
    E. Radius, temperature

9. Balmer lines refer to spectral line emissions from which element?
    A. Hydrogen
    B. Helium
    C. Carbon
    D. Oxygen
    E. Xenon

10. The Milky Way is a _____ galaxy.
    A. Spiral
    B. Barred-spiral
    C. Elliptical
    D. Irregular

11. A very hot star will most likely appear _____ in color to an observer on Earth.
    A. Red
    B. Black
    C. White
    D. Blue

12. The most luminous stars are _____ and _____.
    A. Big, hot
    B. Big, cool
    C. Small, hot

D. Small, cool

13. Megaparsecs are a measure of _____.
    A. Distance
    B. Energy
    C. Time
    D. Speed

14. Luminosity is a measure of_____.
    A. Power
    B. Energy
    C. Distance
    D. Temperature

15. Light years are a measure of _____.
    A. Distance
    B. Volume
    C. Time
    D. Speed

16. Which of the following portions of the electromagnetic spectrum have the longest wavelength?
    A. Infrared
    B. Visible
    C. Ultraviolet
    D. Radio

17. Variable stars are located in an area called the _____ on an H-R Diagram.
    A. Uncanny valley
    B. Instability zone
    C. Metastable zone
    D. Instability strip

18. Supermassive black holes are typically found
    A. At the centers of stars
    B. At the centers of galaxies
    C. In distant galaxies
    D. In interstellar space

19. White dwarfs are held up by
    A. Chemical reactions
    B. Nuclear reactions
    C. Electron degeneracy pressure
    D. Neutron degeneracy pressure
    E. None of the above

20. In an astronomy context, the word "relativistic" means:
    A. Slow
    B. Relative to an inertial reference frame
    C. Relative to a noninertial reference frame
    D. Traveling close to the speed of light

21. The Big Dipper is an asterism that is part of the _____ constellation.
    A. Orion
    B. Cygnus
    C. Ursa Minor
    D. Ursa Major

22. How many constellations are officially recognized by astronomers?
    A. 100
    B. 88
    C. 42
    D. 16
    E. 3

23. Which of the following sequences below correctly describes the evolution of the Sun from young to old?
    A. Protostar, main-sequence, red giant, white dwarf
    B. Red giant, main-sequence, white dwarf, protostar
    C. Protostar, red giant, main-sequence, white dwarf
    D. White dwarf, red giant, main-sequence, protostar
    E. Red giant, main-sequence, red supergiant, protostar

24. Roughly how long does it take a stellar iron core to collapse during a supernova?
    A. About 1 second
    B. About 1 day
    C. About 1 year
    D. About 1 millennium

25. No matter what its mass, a star spends most of its time on the _____.
    A. Asymptotic giant branch

B. Red giant branch

C. Hayashi track

D. Henyey track

E. Main sequence

26. The sun will evolve off the main sequence when:

A. It runs out of helium in its core

B. It completely runs out of hydrogen

C. It builds up an inert helium core

D. It builds up an inert carbon core

27. Stars much more massive than the Sun primarily generate energy through which of the following processes?

A. Combustion

B. Antimatter fusion

C. Proton-proton chain

D. CNO cycle

28. Mass transfer in binary star systems occurs when at least one star overflows its _____

A. Chandrasekhar Limit

B. Eddington Limit

C. Roche Lobe

D. Toomre Limit

29. Stars in the same constellation are _____.

A. The same size

B. The same distance from Earth

C. In the same direction when viewed from Earth

D. The same brightness

30. In a galaxy, where do stars form the most?

A. In its halo

B. In its spiral arms

C. In its nucleus

D. In the dark matter orbiting it

Section B

Use the attached Image Set for the questions in this section. Each part/subpart is worth 3 points for a total of 144 points.

31. (a) Which DSO is shown in Image 1?
    (b) True or false: this is the same DSO as the one shown on the cover of this exam.
    (c) What is the Messier designation for this object?
    (d) This object is expected to collide with the Milky Way within the next 4-5 billion years. After they form, which type of galaxy will they form? Choose from spiral, barred spiral, elliptical, or irregular.
    (e) When these two galaxies collide, would we expect to see an increase, decrease, or no change in the star formation rate? Explain your answer.

32. (a) Which DSO is shown in Image 2?
    (b) Which constellation is it in?
    (c) What reason do most astronomers attribute to this DSO's strange shape?

33. (a) Which image shows the Baby Boom Galaxy?
    (b) What type of galaxy is the Baby Boom Galaxy?
    (c) Which telescope discovered this galaxy?
    (d) Which constellation is the Baby Boom Galaxy in?

34. (a) Which star is shown in Image 3?
    (b) Which image shows the constellation that this star is in?
    (c) Which phase of the stellar life cycle is this star in?
    (d) Based on its mass, how do astronomers expect its life to end?
    (e) Which other image shows this object?

35. (a) The light curve of what object is shown in Image 7?
    (b) In what stage of stellar evolution is this object?
    (c) These objects do not exist above a certain mass. What class of objects represent the more massive counterpart to this type of object?

36. (a) Which image shows the Dragonfish Nebula?
    (b) In what wavelength is this image taken?
    (c) Which telescope took this image?
    (d) This object is difficult, if not impossible, to observe in visible light. Why is that so?

37. (a) Which constellation is shown in Image 12?
    (b) Which famous asterism is a part of this constellation?
    (c) What is the brightest star in this constellation?
    (d) What type of variable star is the star from the previous part?

38. (a) Which image shows the constellation in which both Castor and Pollux are located?
    (b) Between Castor and Pollux, which star is brighter? Which one is given the α designation within the constellation?

39. (a) Which image shows the constellation Perseus?
    (b) What is the name of the DSO found in this constellation that is mentioned on the rules?

(c) The DSO in the previous part is notable for having 30-40 of what type of object?

40. (a) Which star is currently the "North Star"?
    (b) Which constellation is the star from the previous part in?
    (c) What is the name of the phenomenon, pictured in Image 5, that causes the North Star to change over time?

41. (a) Which DSO is shown in Image 14?
    (b) What do astronomers think/expect is at the center of this object?

42. (a) Which image shows the constellation that contains the Big Dipper?
    (b) What is the name of the constellation from the previous part?
    (c) Which DSOs from the rules are in this constellation? Hint: there are two, and stars are not counted as DSOs.

43. (a) Which object is shown in Image 13?
    (b) Which constellation is this object in?

44. Each of the following constellations, name the one star on the rules that they are home to.
    (a) Aquila
    (b) Auriga
    (c) Bootes
    (d) Canis Minor
    (e) Lyra

Section C

Each part/subpart is worth 6 points for a total of 72 points.

45. The Sun has a luminosity of 3.8×10^{26} Watts.
    (a) What is the energy flux from the Sun at Earth in W/m^2? The Earth is 1.5×10^{11} meters from the Sun.
    (b) By what factor would you expect the energy flux to decrease at a distance of 3×10^{11} meters from the Sun, exactly twice as far as the distance in the previous part?

46. A group of astronomy students are studying a star whose blackbody spectrum peaks at 700 nanometers.
    (a) What is its effective (surface) temperature, in Kelvin?
    (b) After looking up this star in a catalogue, the student realize this is one of the brightest stars in the sky. Based on this information, would you expect this star to be on the main sequence?

47. A distant supernova is observed with an apparent magnitude of 13. Follow-up observations show that it is a type Ia supernova, which typically have absolute magnitudes of roughly -19.3.
    (a) Based on this information, how far away is this supernova, in parsecs?
    (b) As astronomer notes that their view of the supernova is blocked by gas and dust in the way, which may affect the distance measurement. Knowing this information, is the supernova closer or farther away than the distance calculated in the previous part?

48. Sun-like stars experience a helium flash, in which the fusion of helium into other elements begins abruptly. The entire helium flash is thought to take only seconds.
    (a) The process through which helium fuses into carbon (and technically beryllium) has a special name. What is it?
    (b) Before the helium flash happens, no fusion is taking place in the core. What force/pressure holds up the inert helium core? Do any other objects in astronomy rely on this force/pressure so that they don't collapse in on themselves?
    (c) During the brief moment that the helium flash occurs, astronomers estimate that the helium-fusing core has a luminositiy of roughly 10^{11} solar luminosities. Why don't we see a giant flash of light from the surface of the star when this happens?
    (d) After the helium flash, is the star still fusing hydrogen? If so, where in the star is this occurring?
    (e) Unintuitively, even though the star is adding a source of energy (helium), its luminosity goes down after the initial burst of energy from the helium flash. Explain why.
    (f) Once the helium flash is complete, in what stage of stellar evolution is the star? In other words, what part of the H-R Diagram is it now on?