Reach for the Stars B

Michigan Region 8
March 12, 2016

Names:

Team:

Team Number:

General Instructions

- There is a separate answer sheet. PLEASE write your answers on the answer sheet.
- You may take the test apart, but put it back together at the end.
- **This test is 125 points total.** Each correct answer is 1 point, unless otherwise specified.
- Section scores will be used as tiebreakers in this order:
  Total Part II → Total Part I → DSOs (I.a) → Stellar Evolution (II.a) → Calculations (II.c) → HR Diagram & Spectral Classes (II.b) → Stars & Constellations (I.b)
- Time is NOT a tiebreaker.

Math-Specific Instructions

- Use the constants provided below.
- Provide answers in the requested units. Answers in other units will not be accepted.
- Full credit will be awarded for answers within ± 10% of the key.

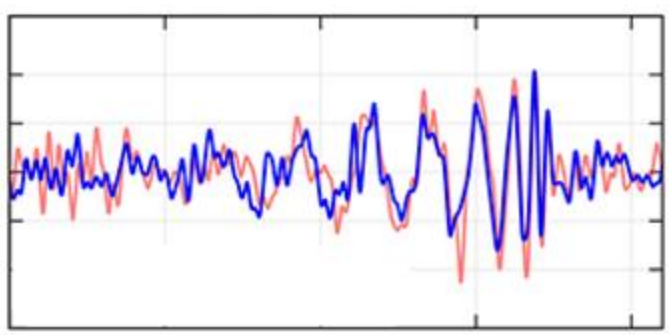
Useful Constants

$b = 3 * 10^7\ nm * K$
$c = 3.00 * 10^8\ m/s$

$1\ pc = 3.25\ ly = 206{,}000\ AU = 3.1 * 10^{16}\ m$
$1\ ly = 0.3\ pc = 63{,}000\ AU = 9.5 * 10^{15}\ m$

$L_{sun} = 3.8 * 10^{26}\ W$
$M_{sun} = 2.0 * 10^{30}\ kg$
$R_{sun} = 7.0 * 10^8\ m$
$T_{sun} = 5800\ K$

Bonus (+1)
What event is depicted in this image? →



Part I

Section I.a – DSOs [35 pts]

1. What is the name of the cluster of massive stars at the center of the DSO in Image [1]?
2. What will happen to the dust and gas in this DSO as those massive stars evolve?

3. Which DSO is shown in Image [2]?
4. Why does the center of this DSO glow with x-rays?

5. What is causing the remarkable amount of star formation in the DSO in Image [3]?
6. The blue and green points are young stars, glowing brightly in what portion of the EM spectrum?

7. Which DSO is shown in Image [4]?
8. What supermassive star in this DSO is known for temporarily being among the brightest stars in the night sky before dimming again?

9. The DSO in Image [5] contains a number of cold, dark clumps of gas and dust that are in the process of forming stars. What is the term for these objects?
10. What is the common nickname for this DSO?

11. Which DSO is shown in Image [6]?
12. What portion of the EM spectrum does this DSO shine brightly in?

13. What is the common nickname for the DSO shown in Image [7]?
14. What about this DSO makes it easier to study high-mass stars in it?

15. Which DSO is shown in Image [8]?
16. What is the term for the long, filament-like structures in this DSO where new stars are forming?

17. What is the term for areas of extreme star formation, like the DSO shown in Image [9]?
18. Several examples of what type of extremely massive and luminous stars have been found in this DSO?

19. Which DSO is shown in Image [10]?
20. Many stars in this DSO can't be seen at visible wavelengths. What portion of the EM spectrum is good for revealing these stars?

21. What cluster of stars at the center of the DSO in Image [11] is illuminating the nebula?
22. What is the common nickname for this DSO?

23. What stage of stellar evolution does the DSO in Image [12] represent?
24. What is the term for the structures in this DSO made of of clumps of gas and dust with long tails pointing away from the center?

25. An artist's conception of which DSO is shown in Image [13]?
26. Why is this DSO so bright in x-rays?

27. What object is producing the strong x-ray emission (light blue) in Image [14]?
28. What type of supernova produced this DSO?

29. When was the DSO in Image [15] first observed?
30. The image shows a pattern of x-ray "stripes". What is thought to be the cause of these stripes?

31. What portion of the EM spectrum was DSO in Image [16] first detected in (and also brightest in)?
32. Unusually, some elements in this DSO are found in clumps rather than spread out evenly. What might this indicate about the initial supernova?

33. Which DSO is shown in Image [17]?
34. This DSO is believed to be a Type Ia supernova, but with what complicating factor (2 possible answers)?

35. Two of this year's DSOs (W3 main and W49) are named from a more obscure catalog. What does this "W" stand for?

36. Quite a few of the images of star-forming regions on this test share the same deep reddish color. What common spectral line produces this red color?

Section I.b – Stars & Constellations [20 pts]

37. Which star is actually a *sextuple* star system, made of three binary pairs?

38. Regulus is quite oblate in shape – its radius measured around the equator is significantly greater than measured around the poles. What causes this equatorial bulge?

39. Which star is shown with its binary companion in Image [18]?
40. What kind of object is the companion?

41. Which star is pictured in Image [19]?
42. Why does this star appear much dimmer than it should?

43. Which star gives its name to a "paradox" where the *less* massive star in a binary system is also the more evolved one?
44. How can this paradox be resolved?

45. Why is α Orionis not actually the brightest star in Orion?

46. Which star's name translates to "the follower" due to the fact that it appears to follow the Pleiades across the night sky?

47. Which three stars on the list are shown in Image [20]? [2 pts]
48. What asterism do these stars form?
49. A similarly named asterism can be seen during the opposite time of the year. Which three constellations are included in this other asterism? [2 pts]

50. Which star is indicated by the arrow in Image [21]?
51. What kind of binary is this star?

52. Which constellation is the galactic center located in?

53. Polaris may not change its position in the night sky, but its brightness definitely changes – what kind of variable star is it?

54. Which star is used as a reference point for the magnitude system (it is often defined to have an apparent magnitude of +0.00)?

Part II

Section II.a – Stellar Evolution [30 pts]

55. What *one* attribute of a star determines its entire evolution?

56. What type of hydrogen causes the distinct spectra of star-forming regions?
57. What type of clusters often lie at the centers of star-forming regions?

58. To form a star, a cloud of dust and gas first needs to collapse. What force causes this collapse?
59. Eventually, the cloud will stop collapsing. What outward-pushing force is responsible for this?
60. What is the term for the state where the inward and outward forces are equal?

61. What are lower-mass pre-main sequence stars called?
62. What are higher-mass pre-main sequence stars called?
63. Which element is found in much larger quantities in pre-main sequence stars than in main sequence stars?

64. Complete the life cycle of a 1 solar mass star:

    ___[a]___ → Main Sequence → ___[b]___ → ___[c]___ → ___[d]___

65. Complete the life cycle of a 10 solar mass star:

    ___[a]___ → Main Sequence → ___[b]___ → ___[c]___ → [___[d]___ or ___[e]___]

66. Why do stars expand in size when they move from the main sequence to the next phase?
67. During this transition, where is hydrogen burning taking place?

68. Low-mass stars cannot continue fusion past what element?
69. High-mass stars cannot continue fusion past what element?

70. What is the cause of a Type Ia supernova?
71. Why do Type Ia supernovae (almost) always have the same absolute magnitude?
72. What kind of remnant is left over from a Type Ia supernova?

73. What is the minimum mass a star must have to produce a Type II supernova?
74. What is the cause of a Type II supernova?
75. One kind of Type II supernova remnant can only be about 2-3 solar masses before it collapses due to its own gravity. What is the name of this mass limit?
76. Some remnants of Type II supernovae cannot be observed directly in any part of the EM spectrum, so how do we detect these objects?
77. What analogy is often used to describe why a pulsar appears to blink on and off as the beam of energy ir produces sweeps across the sky?

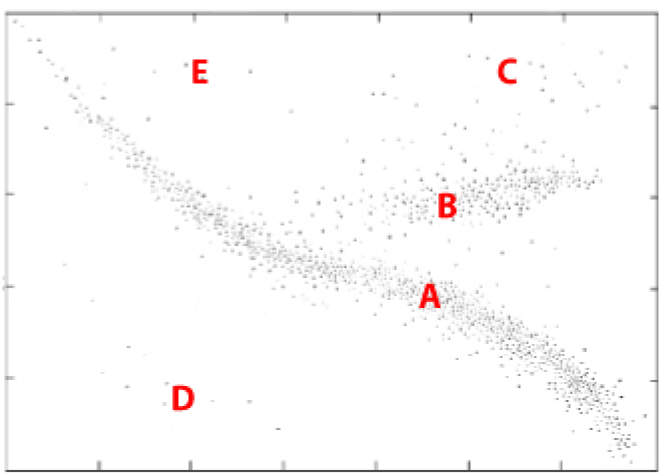
Section II.b – HR Diagram & Spectral Classes [25 pts]

78. What do the H and R stand for in "HR diagram" (must have both answers)?

79. What two quantities may be plotted on the y-axis? [2 pts]

80. Other than temperature or spectral class, what quantity may be plotted on the x-axis?
81. How do we determine this quantity?

82. What types of stars are indicated by the following labels on the HR diagram? [5 pts]



83. Give an example from the DSO list of a star in areas A, B, C, and E of the HR diagram. [4 pts]

84. List the spectral classes in order of *decreasing* temperature. [3 pts]

85. Which spectral class has the strongest hydrogen lines? Weakest? [2 pts]
86. Which spectral class contains stars with a temperature around 7000 K?
87. What spectral class is, by far, the most common?
88. Which spectral class is often associated with stars that are blue-white in color?

89. In addition to spectral classes, stars are also categorized by luminosity classes. Who are the luminosity classes named after?

90. What luminosity class are subgiants?
91. What about white dwarfs?

Section II.c – Calculations [15 pts]

92. A star has a parallax angle of 2.0 mas (milliarcsecond). What is its distance from Earth, in pc?

93. A hypothetical type Ia supernova has an apparent magnitude of +5.4 and an absolute magnitude of −19.6. What is its distance from Earth, in pc?

94. What distance would an object be at, in pc, if its distance modulus were exactly zero?
95. If an object dims by 5 magnitudes, by what factor has its brightness changed?

96. By what factor would a star's luminosity change if…
    a. …its radius expands by a factor of 5?
    b. …its temperature goes up by a factor of 3?
    c. …its radius expands by a factor of 8 but its temperature also drops by half?

97. The solar flux (energy per time, per area) on Earth is about 1 W/m^2.
    a. What would the solar flux be if Earth were at the distance of Mercury's orbit (0.4 AU)?
    b. What if the Earth were at the distance of Jupiter's orbit (5 AU)?

98. A very hot star may have an effective temperature around 30,000 K.
    a. What is its peak wavelength, in nm?
    b. What portion of the EM spectrum is this in?

99. A very cool star may have an effective temperature around 3,000 K.
    a. What is its peak wavelength, in nm?
    b. What portion of the EM spectrum is this in?

100. Star X has a temperature of 10,000 K and a surface area of $1 * 10^{19}\ m^2$. Use $\sigma = 6 * 10^{-8} \frac{W}{m^2K^4}$.
    a. What is its flux, in W/m^2?
    b. What is its luminosity, in W?