# Science Olympiad 2014 - 2015
## Astronomy Test



TEAM NAME: _____

COMPETITOR NAMES: _____

**ALL QUESTIONS ARE SHORT ANSWERS!**
**ALL ANSWERS MUST GO ON THE ANSWER SHEET**
**Challenge: Try to answer all questions without reference materials. It is do-able!**

# Section A: Stellar Evolution and General Knowledge [50 pts.]

1. How does a main sequence star maintain its hydrostatic equilibrium? [2]

2. What is the main source of energy for stars? [1]

   (a) What is the specific source for stars with masses around 1 $M_{sun}$? [1]
   (b) What is the specific source for stars with masses around 6 $M_{sun}$ is called? [1]

3. What does AGB stand for? [1]

4. What is a dredge up? [1]

5. During which phase does the second dredge up occur? [1]

6. The path a star follows after the Hayashi Track and right before the ZAMS is called? [1]

7. (a) What does TOV limit stand for? [1]
   (b) What does the TOV limit describe? [1]
   (c) What is the accepted numerical value for the TOV limit? [1]

8. (a) The hypothetical maximum mass of a star is called what?
       Bonus: What is the formula for this limit?

9. List two factors that affect the Jean's mass for interstellar gas clouds. [2]

10. What is the significance of 1.44 $M_{sun}$? [1]

11. (a) After which stage does the Helium flash occur? [1]
    (b) Why does the Helium flash only occur for sun-like stars (i.e. what is the requirement for a Helium flash to occur)? [1]

12. What does the Schönberg-Chandrasekhar Limit ? [1]

13. What difference in spectra separates Type I SN from Type II SN? [1]

14. Which SN is typically brighter, Type Ia or Type II? [1]

15. (a) What does IMF stand for? [1]
    (b) What does IMF state? [1]

16. How do population II stars compare to population I stars with respect to:

    (a) Age? [1]
    (b) Chemical composition? [1]
    (c) Typical proper motion? [1]
    (d) Distribution in the Milky Way Galaxy? [1]

17. (a) What does a TZO object consist of? [1]
       Bonus: Where was the most recent TZO object discovered?

18. (a) What is thought to be at the center of the Milky Way? [1]

    (b) In what constellation is the center of the Milky Way located? [1]

    (c) What is the object at the center of the Milky Way called? [1]

19. (a) What are the seven main classifications of Main-Sequence stars? [1]
    <u>Bonus:</u> What does WR stand for?

20. What is the most commonly used system of stellar spectral classification? [1]

21. How many modern constellations are there? [1]

22. (a) What law gives the area under a blackbody curve (i.e. the total power emitted from the blackbody radiator)? [1]
    <u>Bonus:</u> What is this formula?

23. What is the Vogt-Russell theorem? [1]

24. What is the Kelvin-Helmholtz contraction and when in a star's lifetime does it occur? Be as specific as possible. [1]

25. (a) What are forbidden spectral lines? How does the mechanism that produces them make them "forbidden"? [1]

    (b) What kind of astronomical objects would emit forbidden lines? [1]

26. Are helium white dwarves a theoretical possibility? Are they likely to exist in the universe? Why or why not? [1]

27. What is the most common phase of matter in the universe? [1]

28. Describe cosmic inflation. [1]

29. What are the typical progenitors for each type of supernova:

    (a) Type Ia [1]
    (b) Type Ib [1]
    (c) Type Ic [1]
    (d) Type II [1]

30. What is the virial theorem? [1]

31. What mechanism explains pulsation in Cepheid variable stars? Who proposed this mechanism? [2]

32. What is the Blazhko Effect? What type of object does it describe? [2]

# Section B: Calculations [25 pts.]

*All work along with the answer goes on the answer sheet. Significant figures count!*

1. Star A has a measured parallax of 381 milliarcseconds. What is the distance to Star A in parsecs? [2]

2. Star B has an apparent magnitude of 5. Star C is 39.8 times brighter than Star B. What is the apparent magnitude of Star B? [3]

3. Star D has a luminosity of 25 $L_{sun}$. If Star D has an observed magnitude of 4.2, what is the distance to Star D in parsecs? [3]

4. Star E and Star F are in a binary system. If they orbit each other once every 19 days, and they are 0.60 AU apart, what is the total mass of the system in $M_{sun}$? [3]

5. Star G has a radius of 30. $R_{sun}$ and an effective temperature of 3000. K. If the sun has a temperature of 5778 K, what is the luminosity of Star G in $L_{sun}$? [3]

6. Star H is an RR Lyrae variable star 2500. ly away. What is the average apparent magnitude of Star H? [3]

7. Star I has a light curve shown below. What is the surface temperature of Star I? [4]
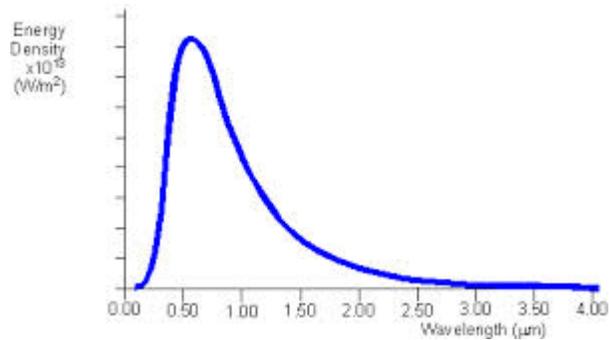


8. Star J is the primary yellow star shown below and Star K is the secondary red dwarf. The time between the two blue lines on the light curve is 15.00 minutes and Star K is moving at 1770. km/s, what is the diameter of Star J in km? [4]
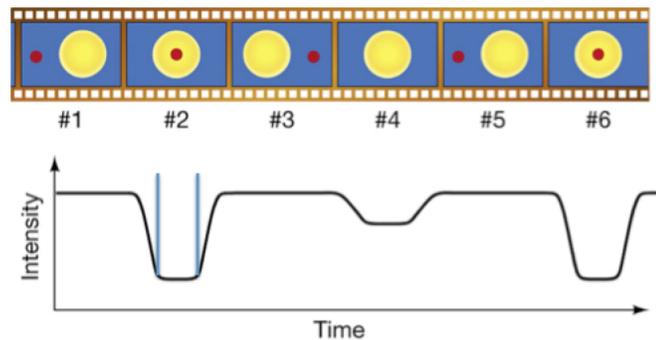
# Section C: More Math Problems [35pts]

*All work along with the answer goes on the answer sheet. Significant figures are not scored but be reasonable!*

1. A Type Ia supernova is observed in a distant galaxy and reaches a peak magnitude of 7.2. If a spectrum were taken of this supernova, what wavelength would the Si II 6150A line be observed at? Assume a Hubble constant of 72 km/s/Mpc. [4]

2. A classical cepheid in a nearby galaxy has a period of 34 days and has an apparent magnitude of 23.2. If a Type Ia supernova explodes in the same galaxy and its apparent diameter is $5.0 \times 10^{-5}$ '' after 5 days, what is the average rate of expansion of the supernova in km/s? [4]

3. At what distance from a 100-W light bulb is the radiant flux equal to the solar irradiance? [4]

4. Barnard's star, named after the American astronomer Edward E. Barnard (1857 - 1923), is an orange star in the constellation Ophiuchus. It has the largest known proper motion ($\mu = 10.3577$'' $yr^{-1}$) and the fourth-largest parallax angle ($p = 0.54901$''). Only the stars in the triple system $\alpha$ Centauri have larger parallax angles. In the spectrum of Barnard's star, the H$\alpha$ absorption line is observed to have a wavelength of 656.034 nm when measured from the ground. The rest wavelength for H$\alpha$ absorption line is 656.281 nm.

   (a) Determine the radial velocity of Barnard's star in km/s. [2]

   (b) Determine the transverse velocity of Barnard's star. [2]

   (c) Calculate the speed of Barnard's star through space. [2]

5. Starship A moves away from Earth with a speed of $v_A/c = 0.8$. Starship B moves away from Earth in the opposite direction with a speed of $v_B/c = 0.6$. What is the speed of starship A as measured by starship B? What is the speed of starship B as measured by starship A? [5]

6. A particular pulsar has a mass of 1.26 $M_{sun}$ and a radius of 12 km. It has a rotational period of 0.046 seconds and a period derivative of $1.5 \times 10^{-13}$. Assume the pulsar has uniform density.

   (a) What is the rotational inertia of this pulsar? [3]

   (b) What is the rotational kinetic energy of this pulsar? [3]

   (c) What is the rate of rotational kinetic energy loss of this pulsar? [3]

   (d) This energy loss takes the form of radio emission. What is this emission called? [3]

**Bonus:** Which astronomer is depicted on the cover page?

Questions C3, C4, and C5 are courtesy of *An Introduction to Modern Astrophysics*