National Science Olympiad
Astronomy C Division Event
31 May 2008
George Washington University
Washington, DC

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TEAM NUMBER: _____

TEAM NAME: _____

INSTRUCTIONS:

1) Please turn in **ALL MATERIALS** at the end of this event.

2) Do not forget to put your **TEAM NAME** and **TEAM NUMBER** at
  the top of all Answer Pages.

3) This event and the answer key will be available on the Wright Center website:
  http://www.tufts.edu/as/wright_center/products/sci_olympiad/sci_olympiad_astro.html

4) Good Luck! And May the Stars be With You!

Section A: Use the 5-page Image Set to answer the questions in this section.

1) **Image G went through three specific types of variability during its evolutionary history.**
    a) **Name the three types of variability in the order that they occurred.**
    b) **What two images contain light curves that represent the first and final stages of variability?**
    c) **Where on the HR diagram are the first two stages of variability located in the order that they occurred?**

2) **UV Ceti is a type of variable star that randomly varies in light intensity in localized areas.**
    a) **Which image contains a light curve produced by UV Ceti?**
    b) **What type of variable star is UV Ceti?**
    c) **Where is UV Ceti located on the HR diagram?**

3) **Image I contains a unique light curve with two types of outbursts.**
    a) **Which Deep Sky Objects produces this type of variability?**
    b) **The systems that produce these types of outbursts are comprised of what components?**
    c) **What two images contain the type of object that would result of the primary component acquired too much mass?**
    d) **Which image contains an example of this type of system?**

4) **AH Leo is a type of variable star that can be used to measure distances to globular clusters.**
    a) **Which image contains the light curve produced by AH Leo?**
    b) **Where on the HR diagram is this type of variable star located?**
    c) **What type of variable star is AH Leo?**
    d) **What area on the HR diagram did AH Leo occupy prior to its current position?**

5) **Image M illustrates a type of variability that results from the accumulation of carbon in the outer atmosphere of a star.**
    a) **Which Deep Sky Object does Image M represent?**
    b) **Which image contains a representative light curve for this object?**
    c) **What type of variable star is this object?**
    d) **The period of this object is getting shorter. Which diagram shows this behavior?**

6) **W Virginis is a Type II Cepheid variable star.**
    a) **Which image shows the classic behavior of this type of variable?**
    b) **What is the difference between a Type II light curve and a Type I?**
    c) **Would you expect the color of a Cepheid variable star to change during the star's oscillation period? If not, why not? If so, describe why the color should change, and the color changes you would expect to see during an oscillation period.**

7) **GRO J1655-40 is an X-ray binary system comprised of a black hole and a main sequence star.**
   a) **Which image shows this system?**
   b) **Image C shows the spectrum of GRO J1655-40. The yellow lines show a model spectrum, and the blue lines show the observed spectrum. In the model spectrum the absorption dips are plotted at their natural wavelengths. Describe the difference between the observed and model spectra and the motion of the wind from this object relative to Earth.**

8) **Compare the two light curves in Images A and L.**
   a) **What is the period of the light curve in Image A?**
   b) **What is the period of the light curve in Image L?**
   c) **These two light curves represent what general type of variability?**
   d) **Which one is produced by the mira R Cygni?**
   e) **Which one is produced by the red giant V725?**
   f) **Which object is the younger of the two, R Cygni or V725?**
   g) **More massive main-sequence stars turn into red giants before less massive main sequence stars. How then is it possible in a binary system to have the more massive star the main sequence star, and the less massive star a red giant?**

9) **The massive supernova SN 2006 gy is illustrated in Image O.**
   a) **What other image contains this object?**
   b) **What is the dimmer object in the image containing SN 2006 gy??**
   c) **What type of stellar core remains at the center of this supernova remnant?**

10) **Image K is an illustration of RX J0806.3+1527 - a binary system with an orbital period that is slowing decreasing by 1.2 ms/year.**
   a) **Which image shows the light curve for this object?**
   b) **Are the two objects slowing down or speeding up?**
   c) **The objects are 50,000 miles apart and moving closer by 2 feet per year. How many years will it take for them to coalesce?**
   d) **Where are these objects located on the HR diagram?**

11) **Describe the behavior of the variable star in the diagram in Image N.**

12) **Draw curves on the O-C diagrams to represent the follow variable star Behaviors.**
   a) **The period lengthens and then shortens but remains periodic**
   b) **The period is periodic and unchanged, but maxima (epoch) changes**
   c) **Correct period, periodic, wrong maxima (epoch)**

13) Star A and Star B are members of an orbital binary star system that is observed to have a separation of 3.0 A.U. and a period of 1.0 years. What is the combined mass of system (in Solar Masses)?

14) The luminosity of Star A is observed to be 8.0 times the luminosity of Star B. If the luminosity-mass relationship for both stars is described by the equation below, what is the distance from Star A to the center of mass of the system (in A.U.)?

$$\frac{L}{L_{Sun}} = \left(\frac{M}{M_{Sun}} \right)^3$$

15) Star C and Star D have equal masses, luminosities, and spectral classes. They are also members of a spectroscopic binary star system that is observed to have a separation of 6.0 x 10^7 km and a period of 10.0 days. What is the orbital velocity of Star C (in km/s)?

16) In the spectrum for Star C, the H_α was measured to have a wavelength of 656.5386 nm compared with a laboratory value of 656.3000 nm. What is the angle between the plane of the systems orbit and the line of sight of the observer (in degrees)?
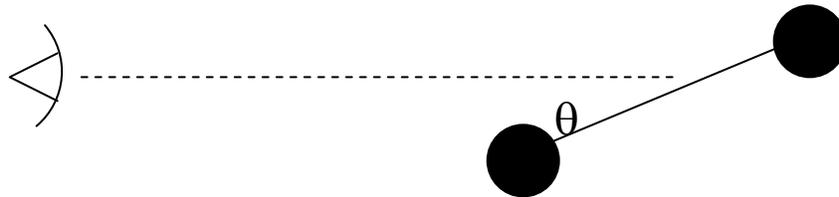
17) Which of the following most closely resembles the light curve produced by the system of Star C and Star D.

(a) (b) (c)
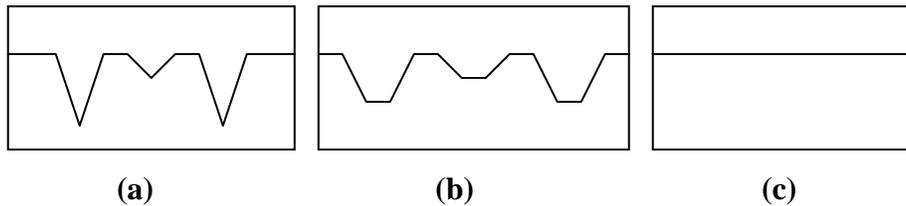
18) Star E is an RR Lyrae variable with surface temperature of 8,500 K. In which wavelength range would an image of the star be brightest?

a) Radio b) Microwave c) I.R. d) Visible e) U.V. f) X-ray g) Gamma ray

19) **Star F is measured to be the same distance away and have 1/2 the angular diameter of Star E. It also is measure to radiate the maximum amount of energy at a wavelength 1/2 that at which Star E does so. How many times more energy doe Star F radiate on the earth's surface in a year than Star E?**

20) **Star G produced the light curve below. What is its period (in days)?**
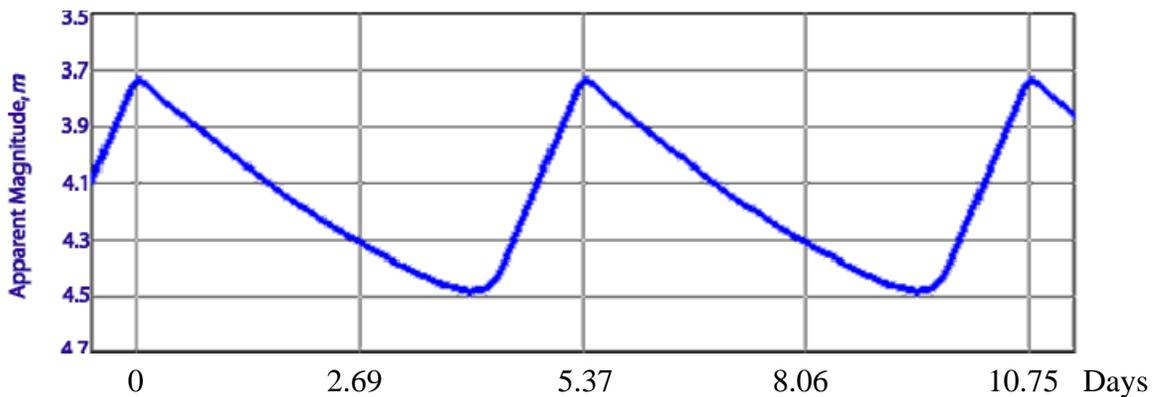
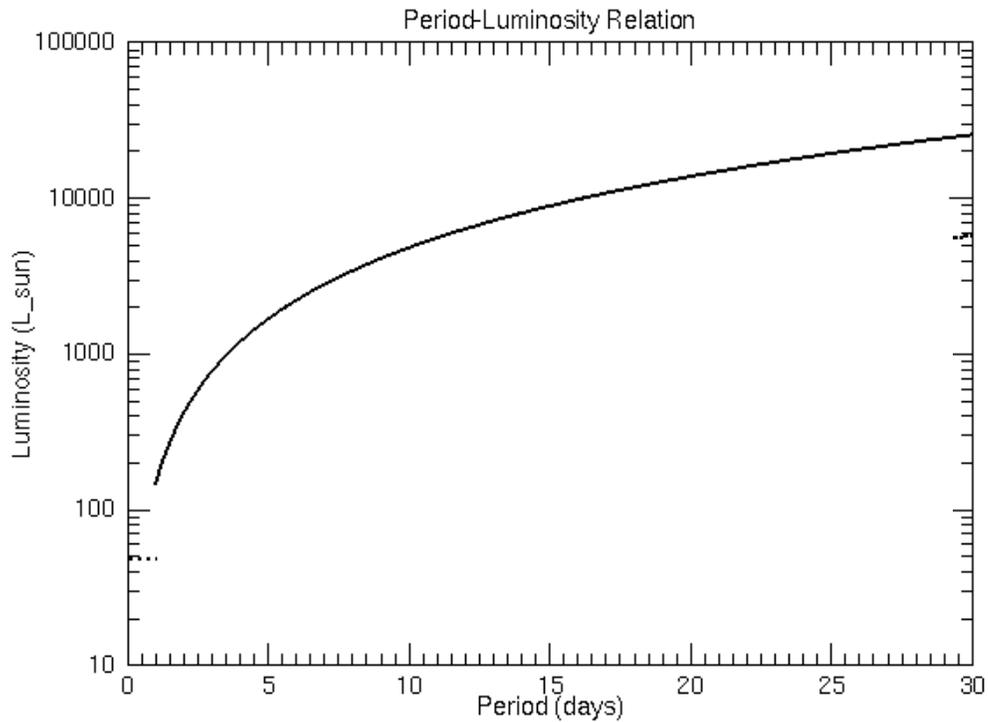

21) **If the light curve for Star G above was used as an observation, what was the calculated period (in days) used to produce the O-C diagram below?**
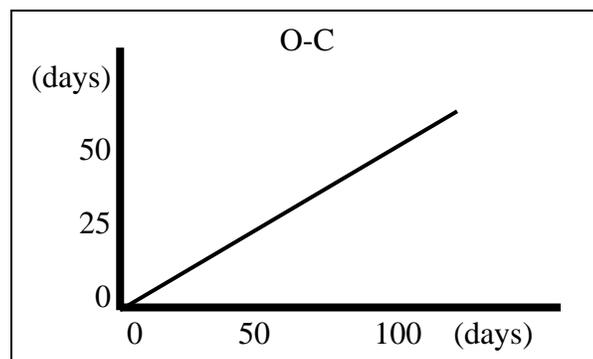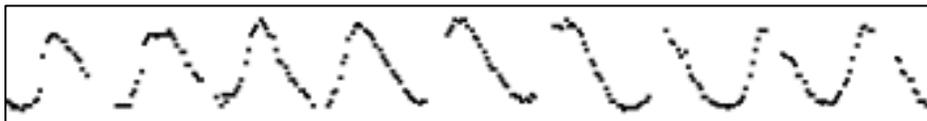
22) Using the chart below and a value of +4.83 for the absolute magnitude of the Sun, calculate the distance to Star G (in parsecs)

Period-Luminosity Relation

23) Star H has a measured parallax of 0.0148 arc seconds and produced the light curve below. What is the distance from Star H to the Sun (in parsecs)?

24) Which of the following spectra is closest to that of Star H?

a)

b)

c)

25) Cluster I is a globular cluster with a parallax of 0.00025 arc seconds and an angular diameter of 25.8 arc minutes. What is the physical diameter of Cluster I (in parsecs)?

26) Cluster II has a parallax of 0.000125 arc seconds and an angular diameter of 25.8 arc minutes. Cluster II also has the same total mass as Cluster I. Approximately how many times smaller is the angular velocity of a star at the outer edge of Cluster II than one at the outer edge of Cluster I?

27) If an X-ray detector measures 1 mW of power from an X-ray binary 2.5 kpc away, how much energy (in mW) would it measure from an equally bright x-ray binary 5 kpc away?

28) Star I and Star J are part of an X-ray binary system with a period of 5.6 days and a separation of 0.095 A.U. Star I has a mass of 1.0 solar mass. What type of star is Star J?