National Science Olympiad

Eastern Washington University
Cheney, Washington
May 20th, 2000

Reach for the Stars

Instructions:

Do not forget to put your team name and number on the cover page of both the question and answer sections.

Record all of your answers on the answer pages. No credit will be given for any responses on the question pages. A blank piece of paper is provided for calculations.

You must turn in all parts of the event: the question section, the answer section, and the paper with your calculations. (You may take the pages apart as long as you reassemble them in correct order before turning them in.)

Have a Stellar Time and may the Stars be With You!

Question A: Changing Positions and Magnitudes of Stars

Use the table and constellation chart on Answer Page 1 to calculate and record your answers for parts (a) and (b) of this question. Record the answers for the remaining parts on Answer Page 2.

Stars all have their own proper motion – the rate at which the direction of a star changes. This change occurs slowly over long periods of time. Listed in the table on page 1 in the answer section are the proper motions of the seven major stars in the constellation Ursa Major, and the stars towards which each of the seven stars of Ursa Major are moving.

a) **Calculate and place in the table the amount of change in proper motion for each star in degrees during a period of 100,000 years.**
b) **Plot the new positions of each of the stars on the constellation chart and connect the stars with a solid line. This is how the constellation of Ursa Major will look in 100,000 years.**
c) **For each of the three images below give the name, the RA and Dec coordinates, and the name of the constellations where each is located.**

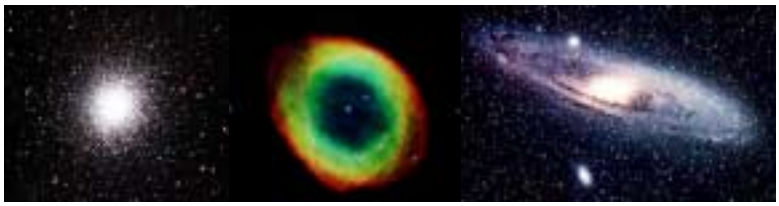
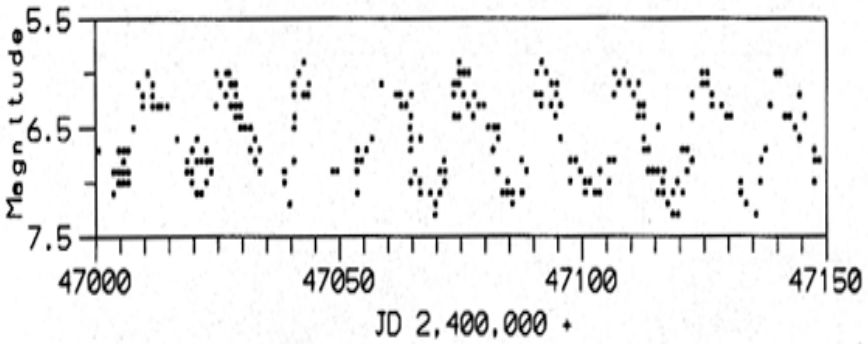


Image 1 **Image 2** **Image 3**

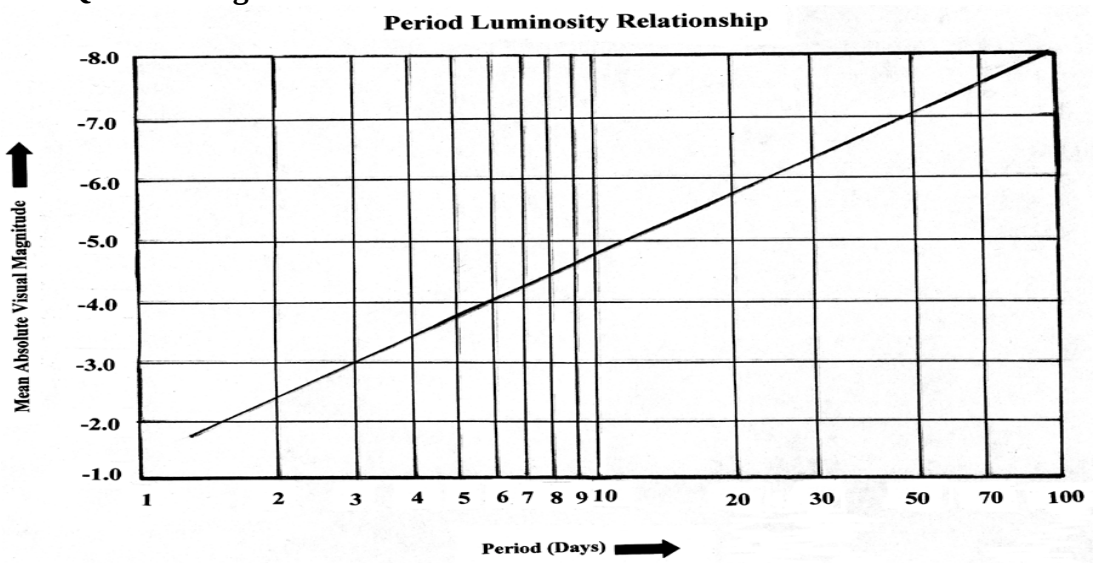
d) **What is the name of the star located at $20^h40'+46^0$? What constellation is the star located in?**

Within this constellation is a star, X Cyg, which produces the following light variation.



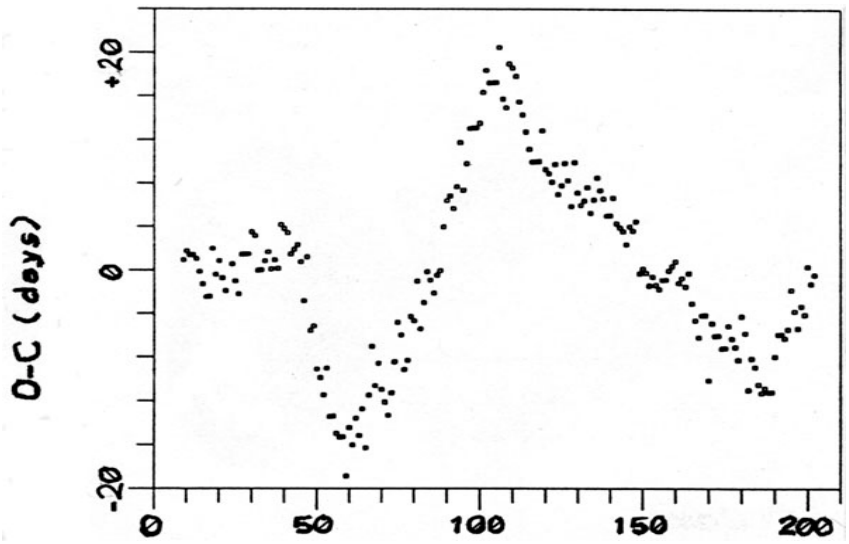
e) **What specific type of star is X Cyg? What is the periodicity? Magnitude at maxima? Magnitude at minima? Use the graph on the following page to determine the distance from Earth to X Cyg.**

Question Page 1



X Cyg was observed over a period of time to determine if the correct epoch (the time of maxima) had been established, and if the period was perfectly periodic. If a star is perfectly periodic, then its cycles can be predicted in advance. These predictions can then be compared with future observations. An "*O Minus C*" (*O – C*) diagram (observed period minus calculated period) is then constructed and the resulting graph shows if the period and epoch of a star is changing. Use the *O - C* diagram below to help answer the following:

f) **Was the epoch calculated correctly? How do you know?**
g) **Is the period changing?**
h) **Describe what is happening between Cycle 0 and Cycle 45; Cycle 45 and Cycle 60; Cycle 60 and Cycle 110; Cycle 110 and Cycle 190.**
i) **What do the slopes of the lines give you for information?**



Question B: A Spectroscopic Eclipsing Binary System

Near alpha Aurigae is located a spectroscopic eclipsing binary system (star A and star B) which have nearly circular orbits about their common center of mass with a period of 88.2 days. The system is oriented such that the orbital plane is viewed edge-on as seen from the Earth. Hydrogen lines are observed in the spectra of both components. Data for three of these lines are given in the table below. (The units are nanometers.) The maximum and minimum observed values of the wavelengths are given for each star. From the Doppler shifts evident in the data, it is clear that the stars have different orbital speeds, hence different masses. From the data, determine:

a) **How fast and in which direction along the line of sight the entire system is moving relative to the Earth.**
b) **The orbital speed of each star and the distance between the two.**
c) **The mass of each star.**

	Star A		Star B	
Laboratory	Minimum	Maximum	Minimum	Maximum
656.273	656.202	656.532	656.332	656.402
486.133	486.080	486.325	486.177	486.228
434.047	434.000	434.218	434.086	434.132

Question C: Star Cluster Ages

Plot part (a) on the H-R diagram on Answer page 3.

a) **The H-R diagram has several main sequence stars plotted. In the table below are listed the spectral types of several stars from three different clusters: the Pleiades, the Hyades, and M15. Plot the stars for each cluster on the diagram, using different symbols for each set of stars. Draw a smooth curve through the data plots for each cluster.**

Pleiades		Hyades		M15	
M_v	Spectral type	M_v	Spectral type	M_v	Spectral type
-2	B9	1	A5	3	F7
0	A0	2	A7	4	F9
1	A1	3	F0	5	G3
2	A4	4	F5	5.6	G8
3	F0	5	G3	6	K1
4	F5	6	K1	6.3	K2
5	G3				
6	K1				

b) **The main sequence lifetime of a star is equal to 10^{10} M (the mass of the star in solar masses) divided by L (the luminosity of the star in terms of the solar luminosity of the Sun.) This gives the lifetime of the star in years. The age of a cluster can be determined by the same method. Use your plotted data, and the tables and graphs provided on the following page (Question page 5) to calculate the age of the three clusters.**

c) **Using the planetarium dome above you, give the coordinates for the three clusters. What specific types of clusters are they? In which general part of the galaxy do these clusters reside? Did the ages for the clusters that you calculated support the type of cluster for each one? Justify your answer.**

Question D: Stellar Identification (Refer to Images on Question page 6)

a) **Name the constellation in Image 15. Two other images are objects found in this constellation. Give the image number, the name of the object, the type of object, and the RA/Dec coordinates for the two objects using the planetarium dome. One of these objects produces one of the light curves. Which object and which light curve?**

b) **Image 19 is an event that occurred in 1987. What is it? Which image(s) show(s) the event over time? One of the images is of the galaxy in which the event occurred. Give the name of the galaxy and the number of the image.**

c) **Give the RA/Dec and name for the object in image 7. Which one of the other images is in this object? What type of object is it?**

d) **What are the name and number and type of object for the image located within the constellation Cygnus?**

e) **Name the object in image 17 and the constellation it is in. One of the other images is centered within this object. Which one? What type of object is it? Which one of the other images contains an object located in this constellation? What is the name of the object?**

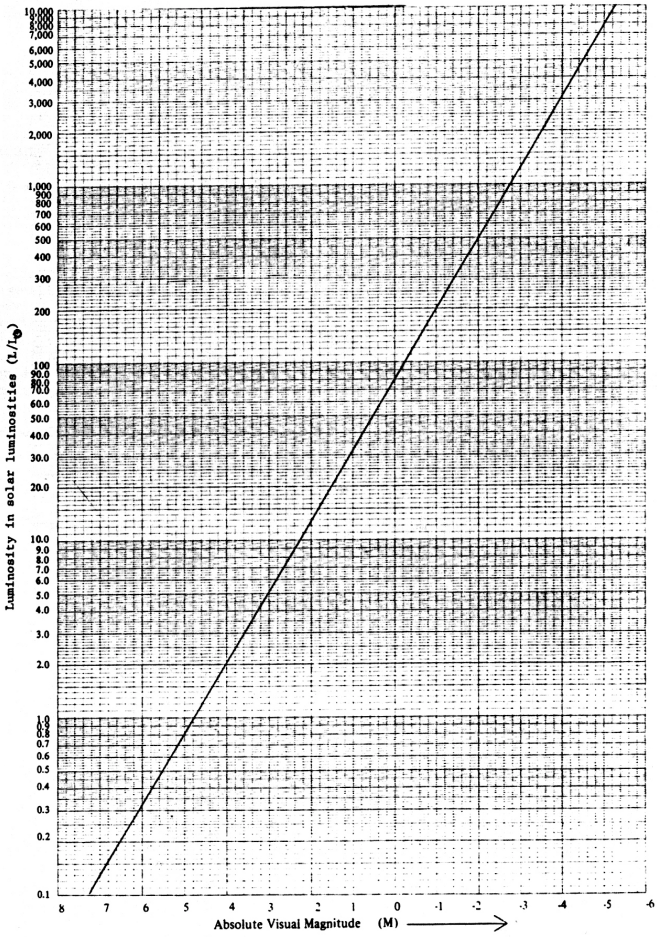
f) **The information in image 21 is associated with which two types of objects?**

g) **Give the names and image numbers of the star clusters.**

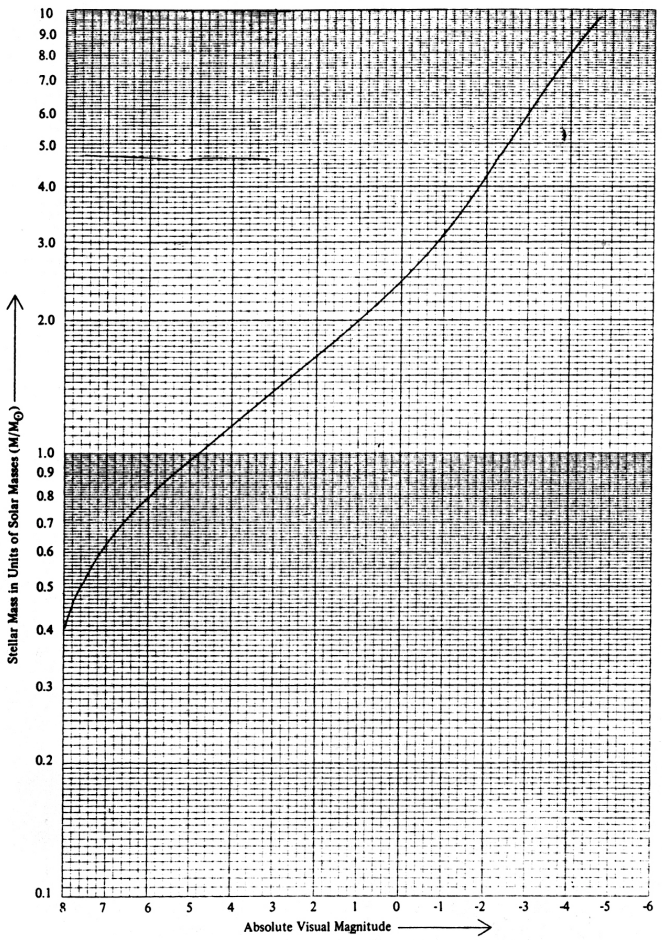
h) **Give the RA/Dec and name of the object in image 13. The distance to this object was determined using the information from which one of the other images?**

Question page 4

Graph 1: LUMINOSITY VERSUS ABSOLUTE VISUAL MAGNITUDE



Graph 2: STELLAR MASS VERSUS ABSOLUTE VISUAL MAGNITUDE FOR MAIN SEQUENCE STARS



Question page 5

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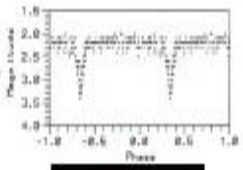

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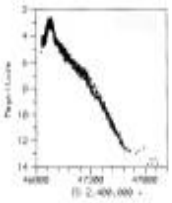

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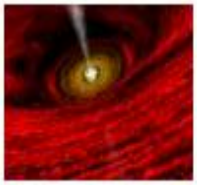

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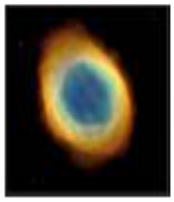

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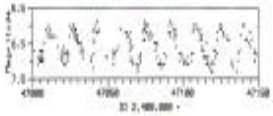

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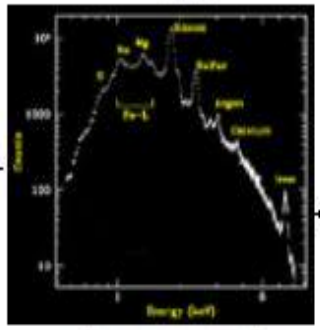

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Question Page 6