SCIENCE OLYMPIAD

Exploring the World of Science

Pennsylvania Science Olympiad

SCIENCE OLYMPIAD

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State Finals 2007
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PENNSYLVANIA SCIENCE OLYMPIAD

STATE FINALS 2007

ASTRONOMY C DIVISION EXAM

APRIL 27, 2007

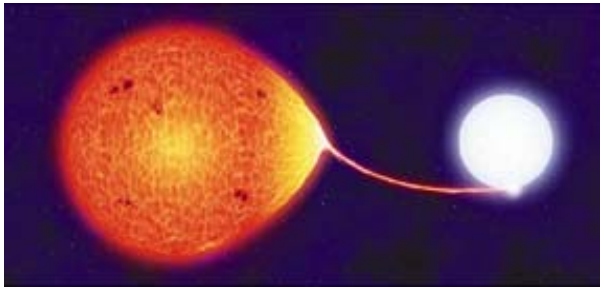
Semiregular yellow pulsating supergiants?

SCHOOL CODE _____ **SCHOOL NAME**_____

IMAGE PAGE 1

1

2



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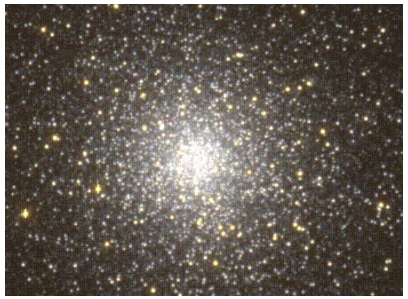

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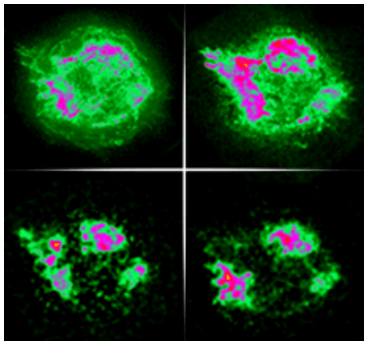

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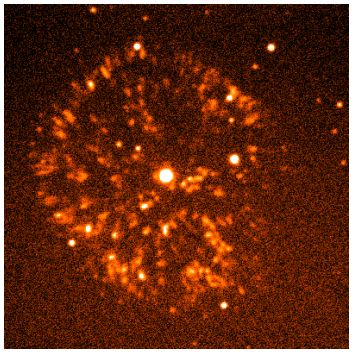

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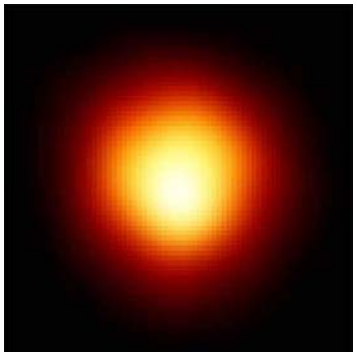

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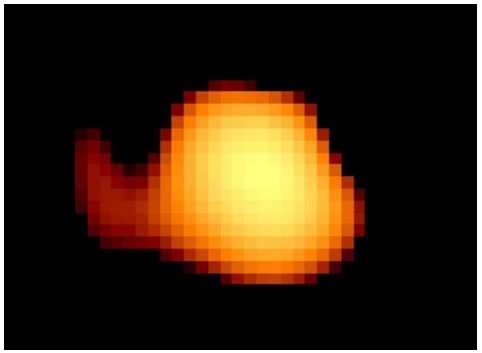

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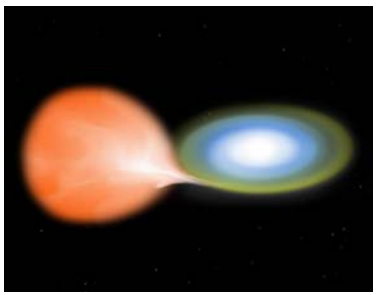

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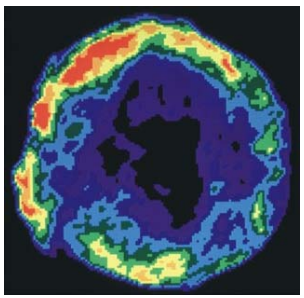

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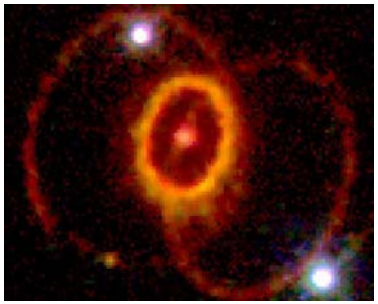

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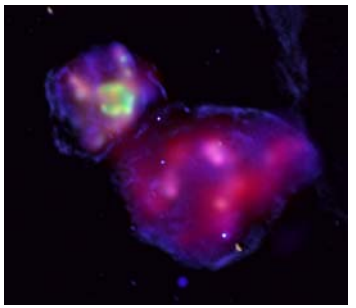


INSTRUCTIONS:

1. Turn in all exam materials at the end of this event. *Missing exam materials will result in immediate disqualification of the team in question*. There is an exam packet as well as a blank answer sheet.

2. You may separate the exam pages. Re-staple them as you submit your materials to the supervisor. Keep the answer sheet separate.

3. *Only* the answers provided on the answer page will be considered. Do not write outside the designated spaces for each answer. You may write in the exam booklet.

4. Include school name and school code number at the bottom of the answer sheet as well as on the title page. Indicate the names of the participants *legibly* at the bottom of the answer sheet. Be prepared to display your wristband to the supervisor when asked.

5. Point values for each question are in parentheses. Tiebreaker questions are indicated with a (T#) in which the number indicates the *order of consultation* in the event of a tie. Tiebreaker questions count toward the overall raw score, and are only used as tiebreakers when there is a tie. In such cases, (T1) will be examined first, then (T2), and so on until the tie is broken. There are six tiebreakers.

6. Pay close attention to the units given in the problem and the units asked for in the answer.

7. When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.

8. The numbers used to refer to specific images are located *above* the associated image.

9. In the bonus section of the answer sheet, name the woman depicted on the cover and note her major contribution to astronomy. 5 bonus points!

10. Nonsensical, mocking, or inappropriate answers WILL RESULT IN DISQUALIFICATION.

11. Use the following constants where applicable.

H_o = 70 km/s/Mpc
c = 3E8 m/s = 3E5 km/s
M_{SUN} = 2E30 kg
T_{SUN} = 5800 K
R_{SUN} = 696000 km
L_{SUN} = 3.85E26 W
1 AU = 1.5E11 m

Questions 1-20 refer to image page 1 and the DSO list as published in the Science Olympiad Student Manual.

(3) 1. What is the name of the object in image 1? What are its Messier catalog number and New General Catalog number?

(1) 2. What is the group of hot young stars called in the region shown in image 1?

(2) 3. Which image shows a semiregular, pulsating red supergiant? What is the star's name?

(2) 4. Which image shows a long-period variable with a period of 332 days? What is the star's name?

(2) 5. Which image shows a planetary nebula? What is it called?

(2) 6. What is the name of the object in image 5 (actually 4 images of the same object)? What wavelength is it imaged in?

(2) 7. Which two images show globular clusters?

(1) 8. What is the approximate age of the two globular clusters?

(3) 9. One of the globular clusters shown has a distance modulus of 13.68. How far away is it in light-years?

(2) 10. What are the names of the two globular clusters shown?

(2) 11. Which image shows a very recent Type II supernova, and when was its explosion observed?

(1) 12. What was the progenitor star of the recent Type II supernova referred to in #11?

(1) 13. What significant event took place about 3 hours before the visible light from the supernova in #11 reached the Earth?

(1) 14. Who observed and described the object in image 11 as a "stella nova"?

(1) 15. What has the object in #14 since been classified as?

(2) 16. What type of object is shown in image 13?

(1) 17. (T5) In which image would T-Tauri stars most likely be found?

(2) 18. Which image shows an artist's conception of the only eclipsing binary on the DSO list, and what is it called?

(1) 19. What is the name of the object shown in image 6?

(1) 20. Which image shows a classical nova just before an outburst?

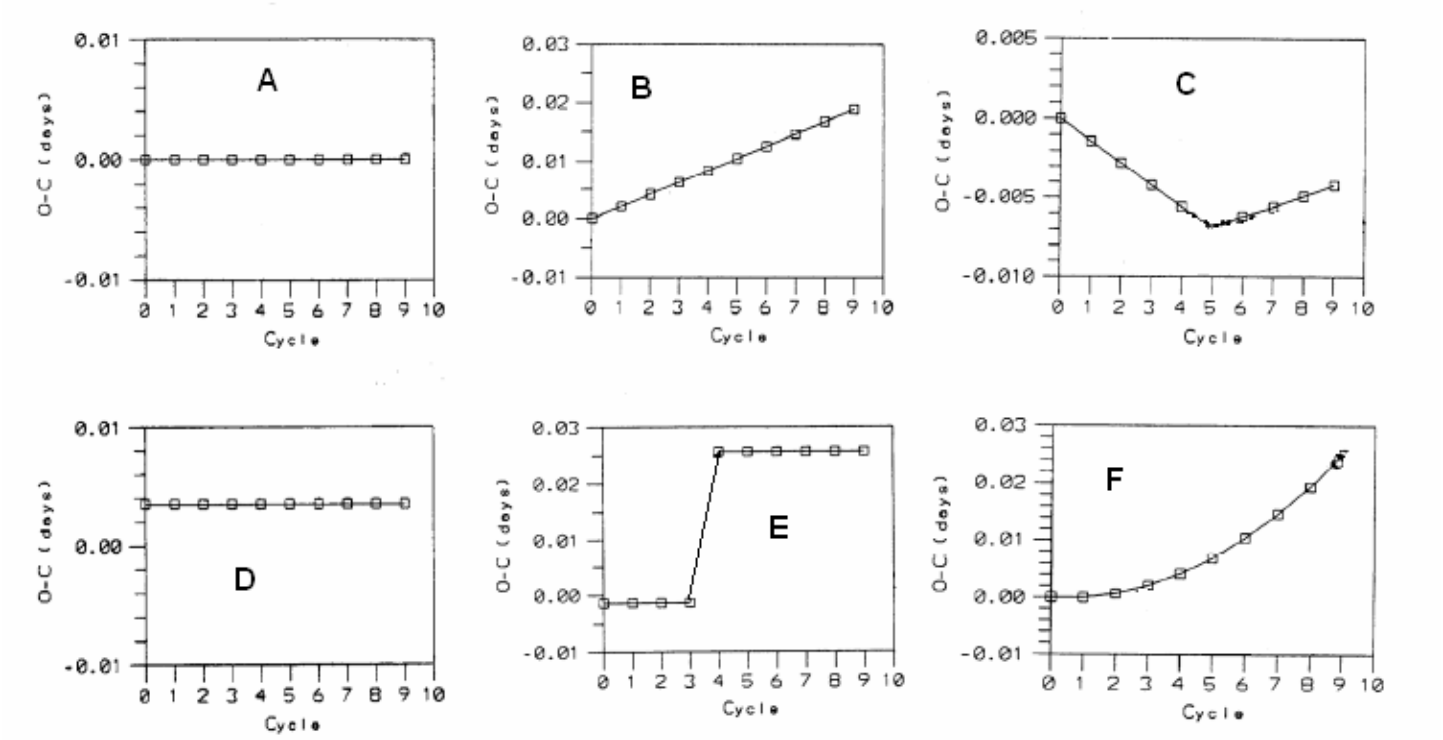
(1) 21. How many parsecs are in one meter?

(1) 22. How many arcseconds are in one degree?

(2) 23. A star has a parallax of 317.47 ± 4.17 milliarcseconds. What is the *range* of its possible distance (in pc) from Earth?

(1) 24. Star A and star B are Cepheid variable stars with identical pulsation periods. Star A is a young, classical Cepheid, whereas star B is an older, W Virginis Cepheid. Which one is more luminous?

Questions 25-30 refer to the following O-C diagrams.



(3) 25. (T4) In which graphs is the estimated period correct?

(1) 26. In which graph is the period changing consistently?

(1) 27. In which graph is the period underestimated?

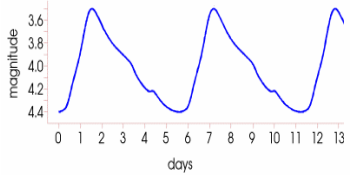
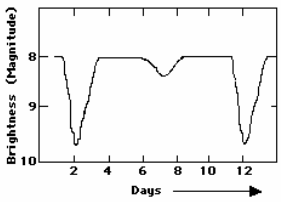
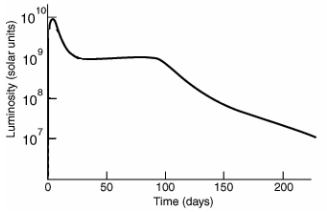
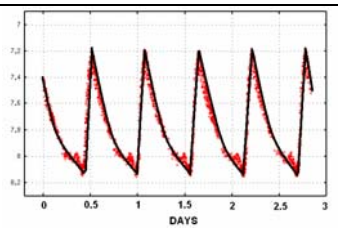
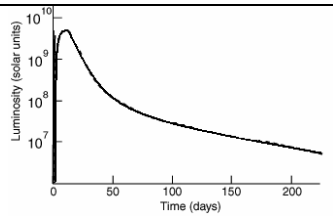
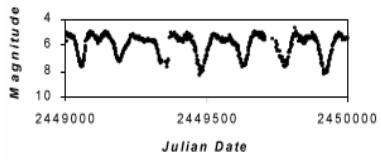
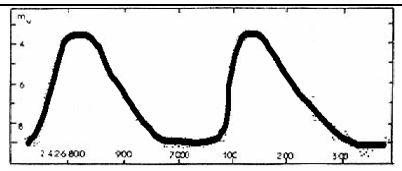
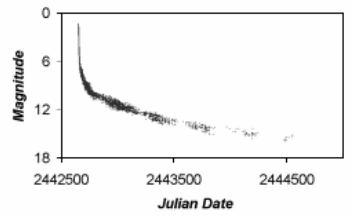
(1) 28. In which graph does the epoch change?

(1) 29. In which graph does the period change suddenly?

(4) 30. In which graphs is the epoch correct?

There are four columns in the table below. In the first column there is a verbal description of a particular type of variable star. The second column lists a series of variable star types. The third column lists periods (or other pertinent information), and the fourth column features a series of light curves.

The descriptions in the first column are numbered 31 - 38; the other column entries are lettered. Associate a letter from *each* of the second, third, and fourth columns with each numbered entry in the first column. Each associated letter is 1 point (so each *number* is worth three points); answers on the answer sheet should be in the form "X Y Z". Each letter is used only once.

31. Binary system in which the orbital plane lies along our line of sight.	**A. RV Tauri**	**I. The time it takes to fade is used to organize this phenomenon into subclasses**	**Q.** 
32. Yellow supergiants with alternating deep and shallow minima. Possibly an intermediate stage between Cepheids and Mira-type variables.	**B. Novae**	**J. Period from 100 to 1000 days**	**R.** 
33. Short-period, very old white giants.	**C. Long period variables**	**K. Period of 0.2 to 1 day**	**S.** 
34. Binary system consisting of a main-sequence star and a white dwarf; brightness increases by up to 16 magnitudes, and fades over years or decades.	**D. Type I supernova**	**L. Spectrum has weak (or absent) Hydrogen lines**	**T.** 
35. Massive stars with high luminosity and a definite period-luminosity relationship.	**E. Type II supernova**	**M. Pulsation in brightness is a result of occultation**	**U.** 
36. Pulsating red giants with highly characteristic spectra.	**F. Eclipsing binary**	**N. Period from 30 to 100 days**	**V.** 
37. Created by the core collapse of a massive star.	**G. RR Lyrae**	**O. Spectrum has strong Hydrogen lines**	**W.** 
38. Binary system in which the white dwarf mass exceeds 1.4 solar masses and carbon detonation ensues.	**H. Cepheid**	**P. Period from 1 to 100 days**	**X.** 

A binary star produces the light curve and the radial velocity diagram shown below. Star A has a temperature of 17700 K and a radius of $5R_{SUN}$, while star B has a temperature of 11000 K and a radius of $1.5R_{SUN}$. The primary eclipse occurs every 3.85 days. The separation of the stars is 1.5E10 m. The extrema on the radial velocity graph are 250 km/s and -190 km/s for one curve; for the other, they are 93 km/s and -33 km/s. Use this information for numbers 39 – 52.

(2) 39. (T6) What is the recessional velocity of this binary star?

(3) 40. What is the orbital velocity of star A?

(3) 41. What is the orbital velocity of star B?

(2) 42. What is the luminosity of star A in solar units?

(2) 43. What is the luminosity of star B in solar units?

(2) 44. What is the absolute magnitude of star A?

(2) 45. What is the absolute magnitude of star B?

(2) 46. What is the apparent magnitude of star A?

(2) 47. How far away is this binary star in parsecs?

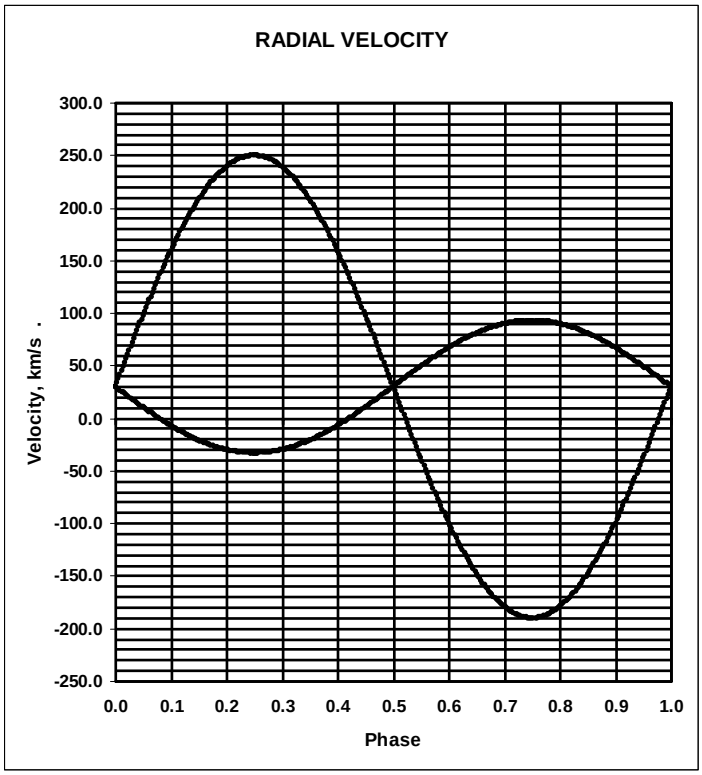
(2) 48. What is the *combined* mass of stars A and B, in solar masses?

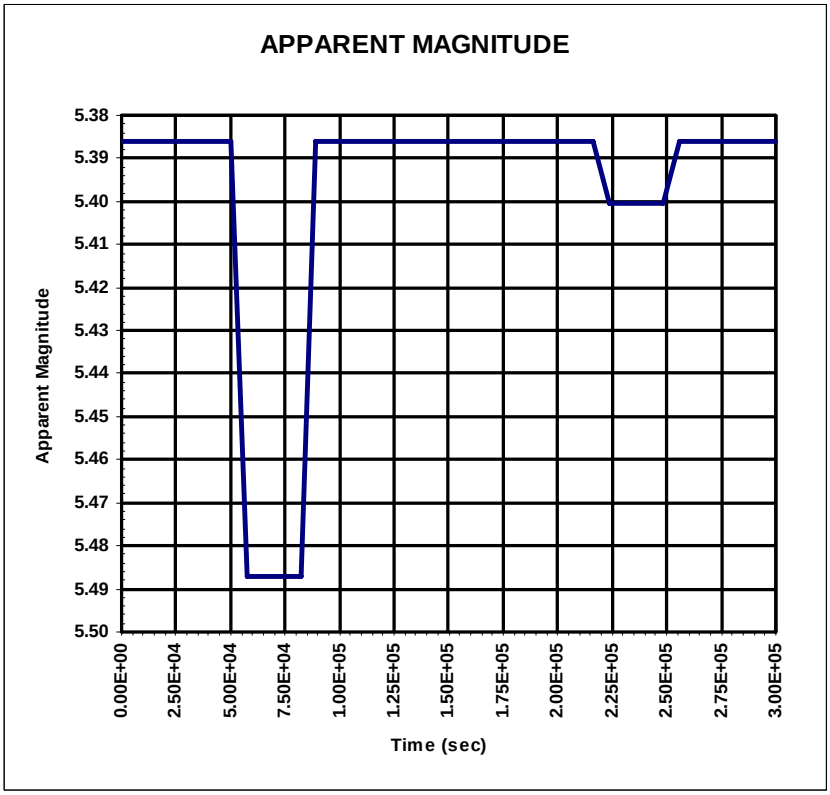
(2) 49. (T1) What is the mass of star A in solar masses?

(2) 50. What is the mass of star B in solar masses?

(3) 51. What is the magnitude of the gravitational force on star A due to star B?

(2) 52. What are the spectral classes of stars A and B, respectively?





The image at below right shows a light curve from a variable star in the galaxy M100. M100 (also known as NGC 4321) is one of the galaxies in the Virgo Cluster, and is located in the constellation Coma Berenices. Use the graph for questions numbered 53-59.

(1) 53. What is the apparent magnitude of this star at maximum?

(1) 54. What is the apparent magnitude of this star at minimum?

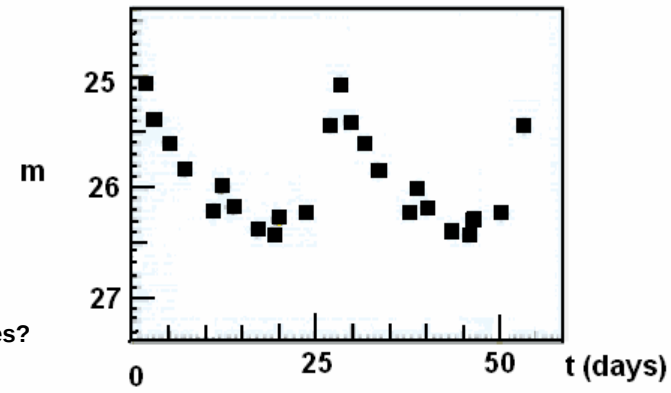
(2) 55. What is the period of this star's pulsation?

(1) 56. Based on the period, what type of variable star is this?

(2) 57. What is the mean absolute magnitude of this star?

(2) 58. (T2) What is the luminosity of this star, in solar luminosities?

(2) 59. What is the distance to this star in parsecs?



Questions numbered 60 – 70 refer to the HR diagram shown.

(1) 60. What are the units across the top of the diagram?

(1) 61. What are the letters across the bottom of the diagram?

(1) 62. What are the units on the left side of the diagram?

(1) 63. What are the units on the right side of the diagram?

(1) 64. In which lettered region would you find the stellar remnant at the center of a planetary nebula?

(1) 65. In which lettered region would you find a cool, pulsating red giant such as Omicron Ceti?

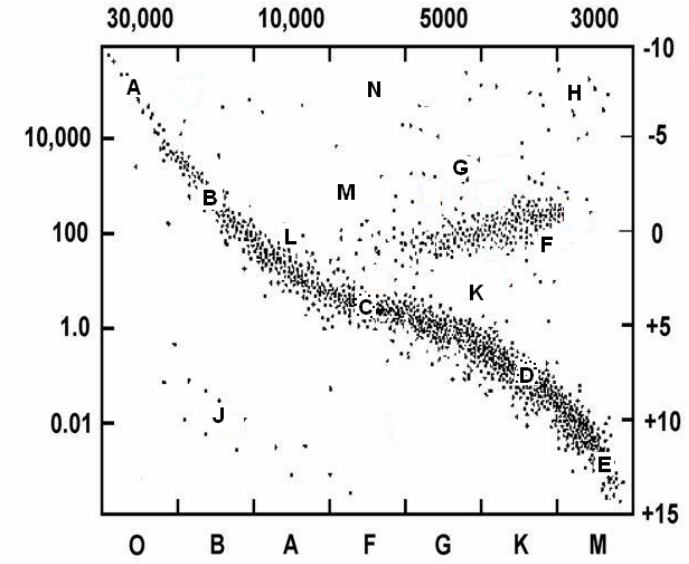
(1) 66. In which lettered region would you find a T-Tauri star, still in its contraction phase?

(1) 67. In which lettered region would you find a cool, semiregular supergiant such as Betelgeuse?

(1) 68. In which lettered region would you find a Cepheid variable with a 12-day period?

(1) 69. In which lettered region would you find an RR Lyrae star?

(1) 70. In which lettered region would you find an RV Tauri star?



The eclipsing binary star X Tri has an estimated period of 0.97532 days and epoch of t_0 = JD 2442502.721. Use this information for numbers 71 - 74. (Data courtesy of AAVSO)

(10) 71. Fill in the table *on the answer sheet* for calculated times of minima and the O-C column.

CYCLE	OBSERVED	CALCULATED	O – C
567	2443053.582		
945	2443420.818		
1021	2443494.658		
1687	2444141.700		
1795	2444246.628		

(5) 72. Construct the O-C diagram using the blank graph provided on the answer sheet. *Clearly* show the trendline for the data.

(1) 73. Which of the following is TRUE regarding the *estimated* period?

A) It is too short B) It is too long

(3) 74. (T3) By how many *minutes* is the estimated period inaccurate?

For problems 75-79, choose from the following options:

I. RV Tauri II. T-Tauri III. Mira type IV. Type Ia supernovae V. Type II supernovae

VI. Dwarf novae VII. Recurrent novae VIII. Classical novae IX. Cepheids X. RR Lyrae

(1) 75. Which of the stars listed above are considered to be *cataclysmic variables*?

A) IV and V B) II, III, IX, and X C) I, IV, V, and VIII D) II, IV, V, VI, VII, and VIII E) II, III, IV, IX, and X

(1) 76. Which of the stars listed above are pre-main-sequence stars?

A) I and II B) VI, VII, and VIII C) IX and X D) III, IX, and X E) II only

(1) 77. Which of the stars listed above are *definitely* binary or multiple-star systems?

A) II, IV, and V B) VI, VII, and VIII C) I, II, IX, and X D) III, IV, V, VI, and VIII E) IV, VI, VII, and VIII

(1) 78. Which of the stars listed is characterized by an accretion disk that becomes unstable and collapses down onto a white dwarf?

A) VI B) II C) V D) VII E) VIII

(1) 79. Which of the stars listed are characterized as *pulsating variables*?

A) I, II, and III B) I, III, IX, and X C) II, IV, and V D) IX and X E) VI, VII, and VIII

(1) 80. What's your favorite variable star?