2012 New York State Science Olympiad
Astronomy - Event #2

Directions, Rules, Guidelines, and Suggestions:

1. Please write your team name and number on *each page* of the test. This is especially important if you separate the test.
2. Write team member names in the designated spaces, on the next page.
3. As stated in the official rules, **each team member** is permitted **either** a three-ring binder **or** a laptop computer. As such, each participant should have his/her resource in front of him when time begins
4. Clearly indicate your answer and process, especially for numerical problems. Ambiguity will result in points being docked.
5. Point values are notated after each question in parentheses.
6. Partial credit will be given for many questions, especially short answer and numerical problems, so feel free to guess or simplify the problem to obtain an approximate solution.
7. There are five (5) problems that will be used as tie-breaker questions. Such questions are notated with the numerical superscripts 1 through 5. The question notated with the superscript 1 will be used as the first tie-breaker; the question notated with the superscript 2 will be used as the second tie-breaker; and so on. These questions are designed to sample your knowledge of a wide variety of subcategories of knowledge, at several different levels of expertise.
8. If you decide to work separately and remove pages, please put the test back in order before submitting them to the proctor.
9. No formulas are provided. You are expected to have prepared such resources ahead of time. So, please don't ask for formulas!
10. You are expected to stop working when time has expired. You will be given warnings when there are thirty minutes remaining, fifteen minutes remaining, five minutes remaining, and one minute remaining. As such, there will be no excuses for students continuing to work, and such conduct may result in disqualification, at the discretion of the proctor and/or tournament director.
    a. In particular, when time has expired, pens, pencils, calculators, and resources should be put down.
    b. At this time, the only action that students should take is to order their test papers, if necessary.
11. Communication between teams is prohibited while tests are out. This includes the time before testing has actually begun, and between time being called and the collection of the last test. Egregious and/or repeated violations of this rule will be dealt with strictly.
12. Do not be discouraged if you do not finish in the allotted time, as this test is designed to be very difficult, in order to differentiate between the top teams.
13. Please remove this front page before leaving the room, and take it with you, so that you can contact the event writer with questions.

This event was written by Zach Pace, a physics and mathematics major from the University at Buffalo. Please contact him with questions about content, and if you wish to obtain a detailed answer key. He can be reached at zpace21@gmail.com

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Team Member 1: _____

Team Member 2: _____

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1. Application of Physical Principles to the Detection of Exoplanets

a. Explain how the Doppler Effect can be used to detect exoplanets (3 points)

b. Explain how exoplanets can be detected as they transit a star (2 points)

c. Which space telescope, launched in March 2009, detects exoplanets using both of these methods? (2 points)

d. What three constellations is the spacecraft surveying? (1 point apiece, 1 point for all three)

d. Explain the need for a long mission lifetime for Kepler, and discuss why only short-period planet candidates were initially found (4 points)

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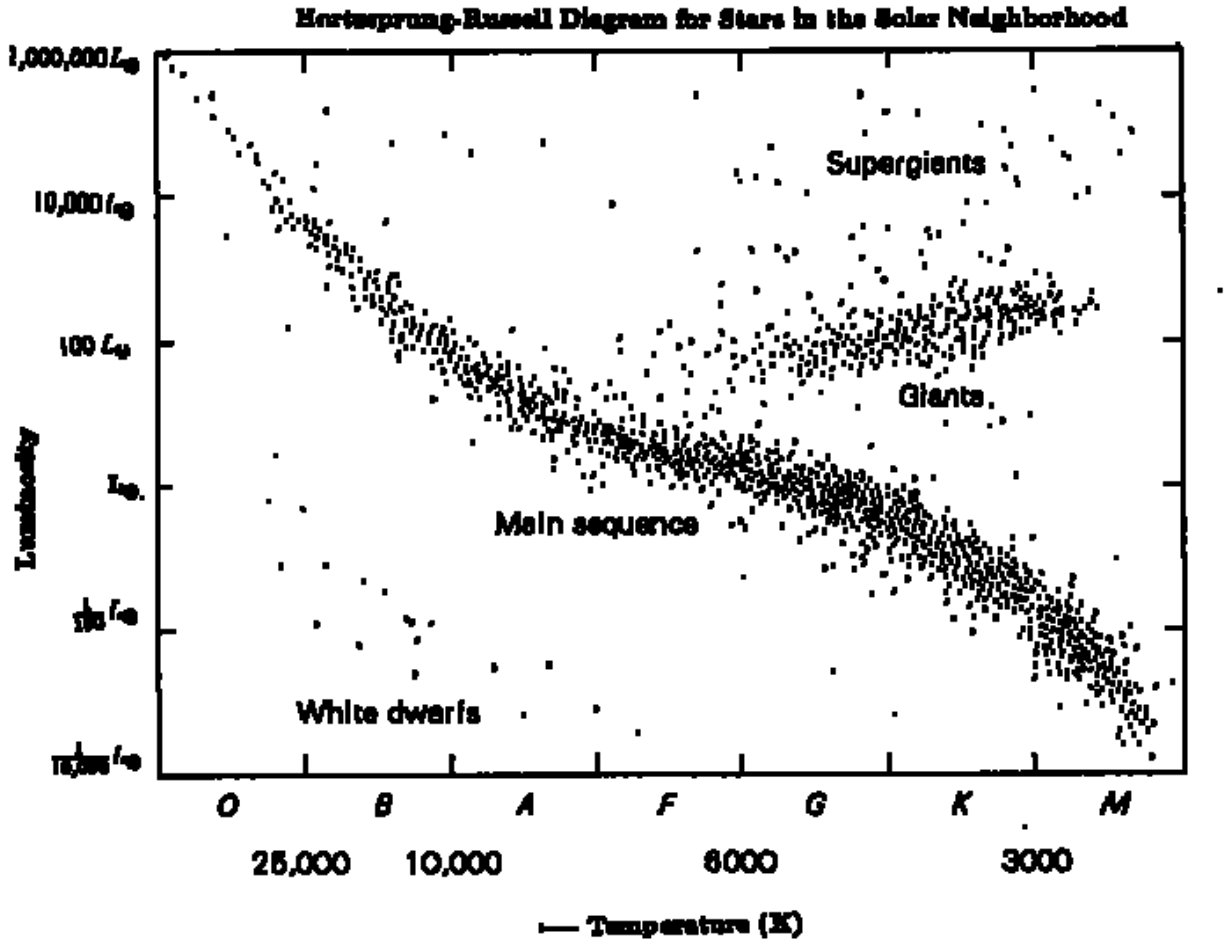
2. Variable Stars - General Proficiency

a. Label the approximate locations/regions of the following classes of variable stars on the H-R diagram below: Classical Cepheid, RR Lyrae variable, W Virginis subclass, RV Tauri subclass, Yellow Hypergiant, Mira variable, Alpha Cygni variable (1 point each, 1 additional point for having all of them)[1]



b. Name and describe the mechanism by which Cepheid Variables oscillate--hint: it has to do with the opacity of a particular gas, at different temperatures (5 points)

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c. Consider 2 Cepheid variables with periods of 4 days and 35 days.

i. What are their absolute magnitudes, within .1 magnitudes? (2 points each)

ii. What are the approximate peak radiant wavelengths of those stars, assuming they lie in the center of the Cepheid instability strip? (2 points each)

iii. Predict the B-V color indices of these stars (3 points each)

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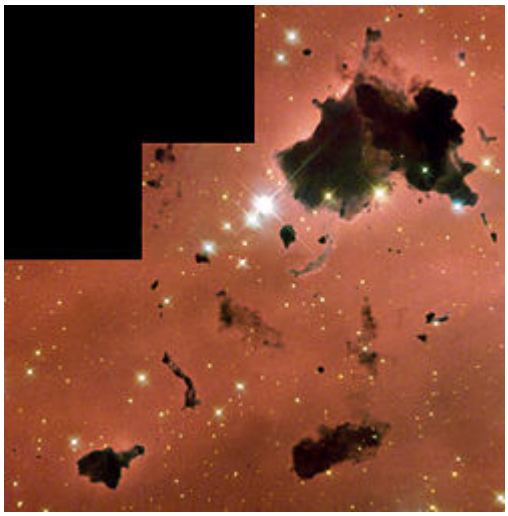
3. Star Formation and evolution

a. Beside each of the following images, label as a Bok Globule, Herbig-Haro Object, planetary nebula, type I-a supernova, type II-l supernova light curve, type II-p supernova light curve, supernova remnant, Wolf-Rayet star (1 point each):



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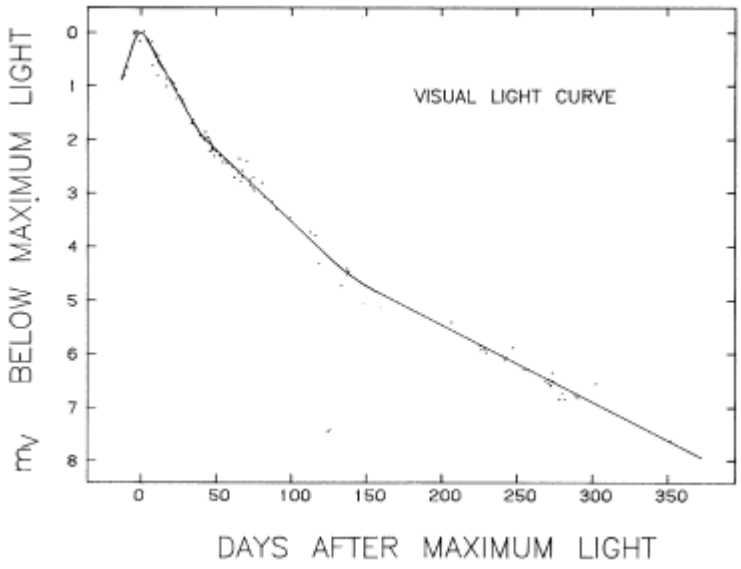

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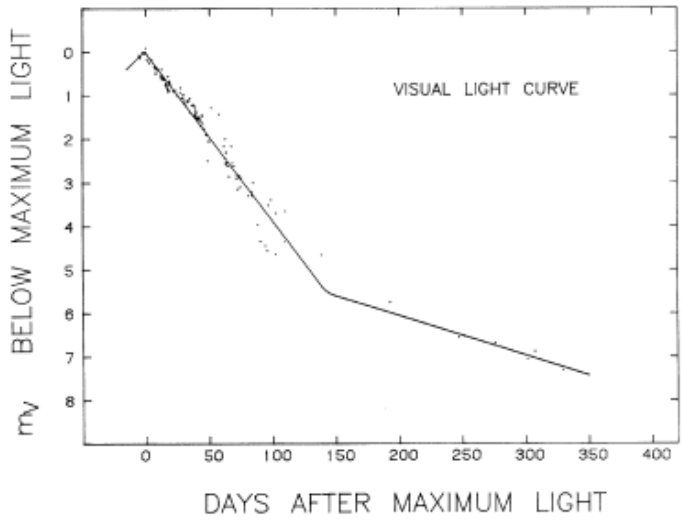

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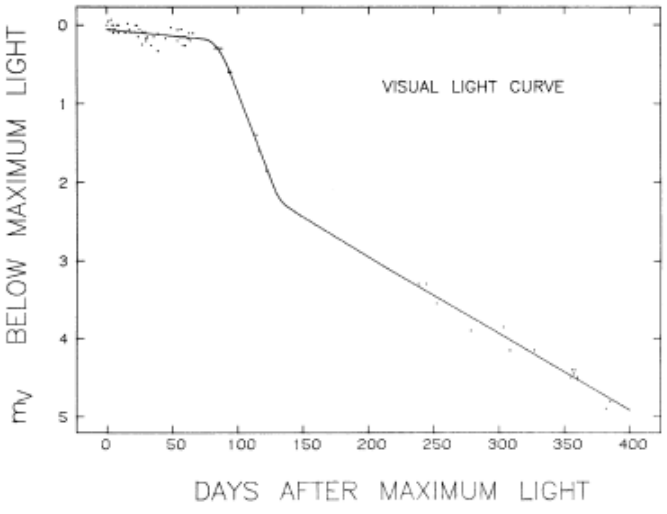

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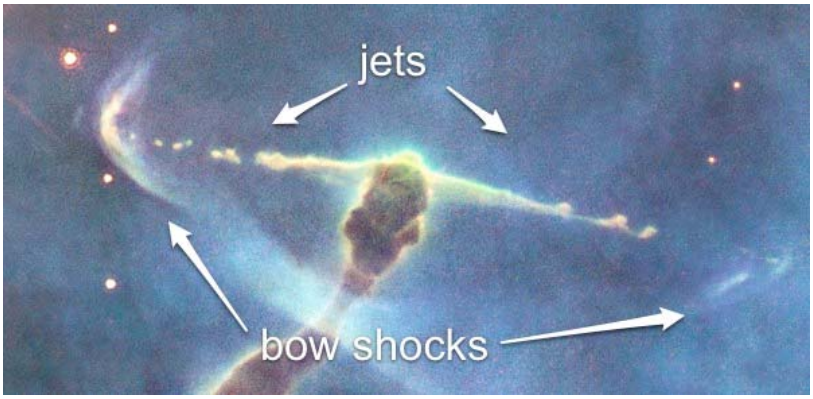

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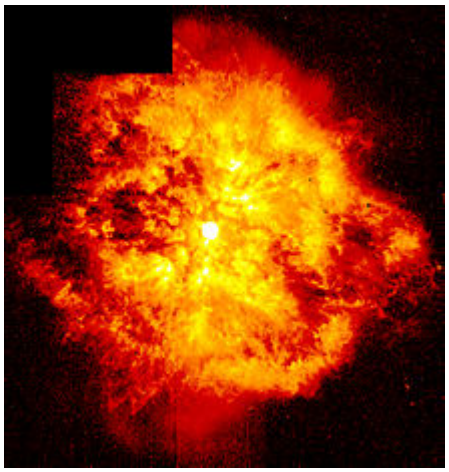

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b. What is responsible for preventing white dwarves and neutron stars from collapsing into black holes? Hint: the concept is similar, but they are distinct processes (3 points).[3]

c. Qualitatively describe how star mass is related to a star's luminosity and lifetime on the main sequence (3 points).

d. Briefly explain why star-forming regions are more likely to be observed in galaxies like the Antennae (3 points).

e. What are the two most common types of stars in the Milky Way? Why are they mostly unobserved? (4 points)

4. Astronomical distance measurements and RR Lyrae stars

a. Consider an RR Lyrae star with a period of .5 days. Obtain a value for its absolute magnitude (2 points).

b. Calculate the distance in parsecs to this hypothetical star, if it appears to have a magnitude of 10. Do not account for interstellar extinction (3 points).[4]

c. Convert the distance obtained in part b to light-years, kilometers, astronomical units, and Bohr radii (1 point each)

d. The parallax of this star is measured to be 1.17 milli-arcseconds. Calculate its distance based on this information (2 points)

e. Would you be more likely to find this star in a globular cluster or an open cluster? Explain why (3 points)

f. Briefly describe the impact that the Blazhko effect has on some RR Lyrae-type stars. In what star was it first discovered? (4 points)[2]

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5. General Information about Astronomical Objects

a. Give the coordinates of the following objects, in RA (±10 arcseconds), Dec (±10 arcseconds), and distance from the solar system, in lightyears (where indicated, ±100 ly) (.5 points per piece of information)

Object	RA	Dec	Distance
RX J0806.3+1527			
Rosette Nebula			
CH Cygni			
M15			
Carina Nebula			N/A
U Scorpii			N/A

b. Give the constellation in which the following objects are located (.5 points per object)

Object	Constellation
DEM L238	
SNR 0509-67.5	
NGC 2440	
Tycho's Supernova Remnant	
Kepler's Supernova Remnant	
The Mice	

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c. Match each of the following spectral classes with the color that a star of that class would appear to the human eye, and the representative example of that spectral class (colors may be used more than once, .5 points per piece of information).

COLORS: RED, YELLOW, WHITE, BLUE
EXAMPLE: Spica, SIMP 0136, Canopus, Epsilon Eridani, WISE 1828+2650, Sigma Orionis A, Sol, Vega, Barnard's Star, V838 Monocerotis

Spectral Class	Color	Representative Example
O		
B		
A		
F		
G		
K		
M		
L		
T		
Y		

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d. Draw V838 Monocerotis as it appeared in May 2002, and as it appeared in February 2004 (4 points).

May 2002	February 2004

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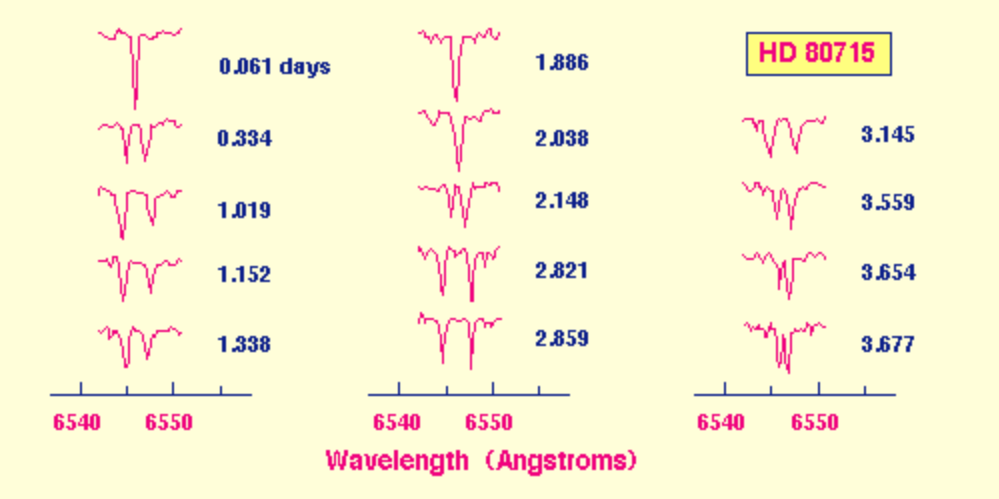
6. Application of Mechanical Concepts



a. Consider a system of two identical stars in mutually circular orbits, with a time-dependent absorption pattern illustrated above. As time progresses, why does the spectral line at 6545 Angstroms seem to split and then recombine? What can we infer about the period of the binary system? (5 points)

b. From this data, what is the approximate orbital velocity of the two stars? (4 points)

c. Estimate the radius of the stars' orbit around their mutual center of mass, in astronomical units (3 points)

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