

Mentor Invitational Division C Astronomy February 11, 2017

Team Name _____

Team Number _____

Participant 1 _____

Participant 2 _____

General Instructions.

Make sure your team name and number is on each piece of paper you turn in.

Please show your work or at least your method for any problems that require calculations. If you need more space than is provided, use the back of the sheet, but indicate that that you have done so in the provided answer space. Partial credit will be awarded, if deserved. Make sure your answer uses the units requested by the problem.

Points per Page

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

Total Points _____

Possibly Useful Information

Data for the Sun

Mass $\cong 2 \times 10^{30}$ kg

Radius $\cong 7 \times 10^5$ km

Luminosity $\cong 3.8 \times 10^{26}$ W

Temperature = 5778 K

Spectral Type G2V

Absolute U band magnitude $M_U = 5.61$

Absolute B band magnitude $M_B = 5.48$

Absolute V band magnitude $M_V = 4.83$

Absolute R band magnitude $M_R = 4.42$

Absolute I band magnitude $M_I = 4.08$

Absolute J band magnitude $M_J = 3.64$

Absolute H band magnitude $M_H = 3.32$

Absolute K band magnitude $M_K = 3.28$

Astronomical Unit $\cong 1.5 \times 10^8$ km

Gravitational Constant $G = 6.67408 \times 10^{-11}$ m³ kg⁻¹ s⁻²

Boltzmann Constant $\kappa = 8.617\ 3303 \times 10^{-5}$ eV K⁻¹

Hubble's Constant $H_0 \cong 72$ km s⁻¹ Mpc⁻¹ (kilometers per second per megaparsec)

Absolute V Magnitude of a Type 1a supernova $M_V \cong -19.3$

The Julian Day on February 11, 2017 at 7:00am EST is 2457796

This year's Objects

J075141/J174140

NGC 2440

M15

NGC 2392

Henize 2-428

HM Cancri

SNR 0509-67.5

Henize 3-1357

Sirius A & B

Omicron Ceti

(Stingray Nebula)

NGC 1846

SN 2011fe

Tycho's SNR

SNR G1.9+0.3

SS Cygni

Point Values for the questions:

1a 2

1b 2

1c 2

1d 2

1e 2

1f 2

1g 2

1h 4

2a 2

2b 2

2c 2

2d 3

2e 4

2f 2

3a 2

3b 2

3c 3

3d 4

4a 2

4b 4

4c 2

4d 3

5a 2

5b 4

5c 5

5d 5

5e 3

6a 2

6b 2

6c 2

6d 2

6e 5

6f 5

7 5

8 6

Total Points = 105

Tie Breaker 1 1e

Tie Breaker 2 2g

Tie Breaker 3 4b

Tie Breaker 4 5c

Tie Breaker 5 7

Tie Breaker 6 6f

Tie Breaker 7 3d

1 Team Name _____

Team Number _____

1 This is an image of one of our objects.



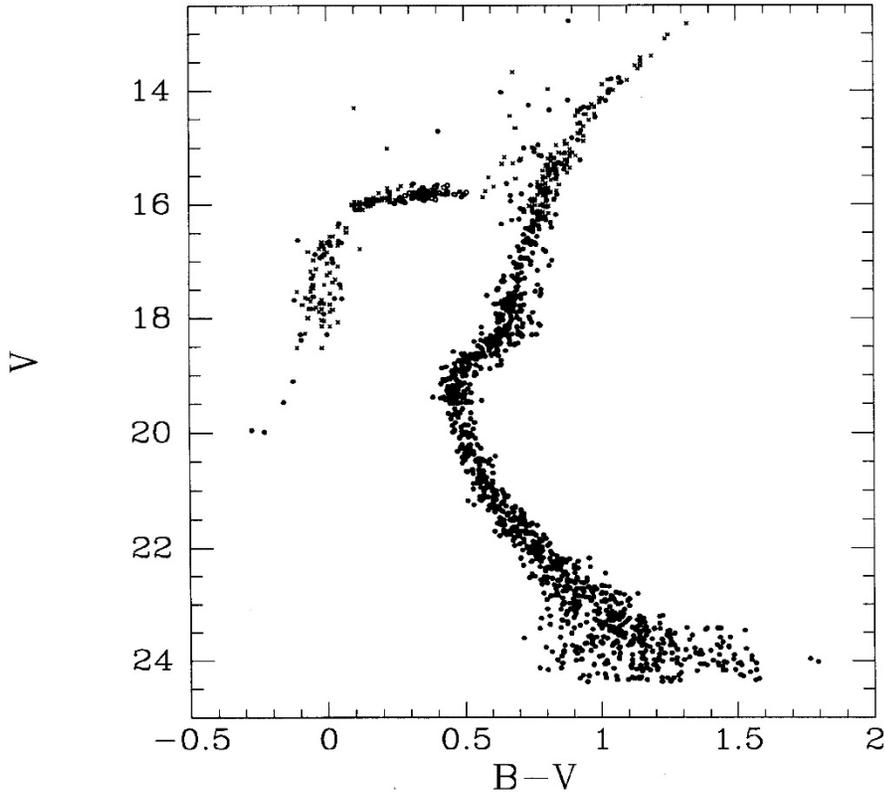
- a Which of our objects is this? _____
- b Which region/regions of the electromagnetic spectrum are represented in this image? Mark the box of the appropriate spectral regions. 1 point for each correct. -1 point for each incorrect region. Total score cannot go below Zero points.

Region	X-ray	UV	Visible	Infrared	Radio
Present					

- c There is an blue-green object below and to the left of the center of the image, marked between two red lines in the image. What sort of an object is this? _____
- d What is the name of the marked object? _____
- e What is special about the marked object? _____

Total Points for this page _____

This is a plot of the observed V band magnitude and B-V color for stars associated with this object.



f What is the name of this sort of plot? _____

g Using what you know about the B-V color of the Sun, mark the diagram with a dot labeled "SUN" on the Main Sequence of this plot where a star just like Sun would fall if it was a part of this object.

h Now, use the V magnitude that is associated with the point you plotted in part f and find the distance in parsecs (pc) to this object.

3 Team Name _____

Team Number _____

2 This is an image of one of our objects.



a Which of our objects is this? _____

b Which region/regions of the electromagnetic spectrum are represented in this image? Mark the box of the appropriate spectral regions. 1 point for each correct. -1 point for each incorrect region. Total score cannot go below Zero points.

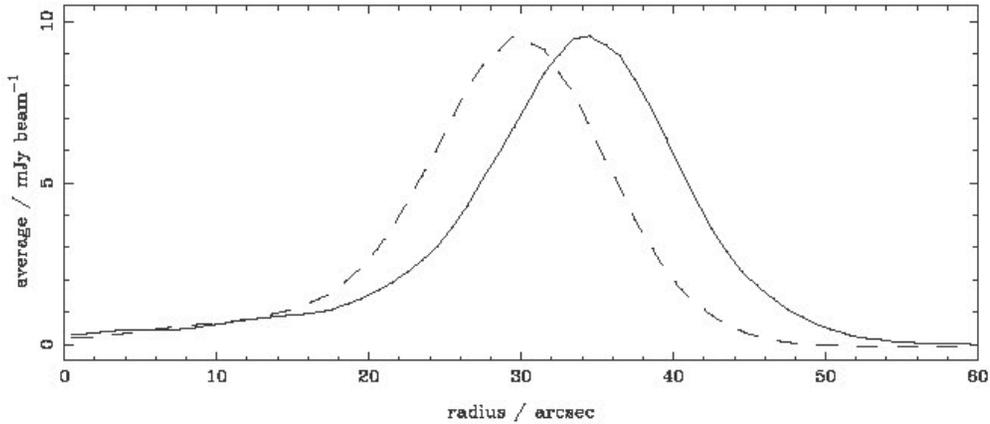
Region	X-ray	UV	Visible	Infrared	Radio
Present					

c What sort of object is this? _____

d What is special about this object?

Total Points for this page _____

This object has been observed for some time. This is a plot comparing a radial averaging of the intensity of the detected radiation from the object versus distance in arcseconds from the center of the detected radiation at two different times, showing the expansion of this object with time. The solid line represents observations made in 2008. The dashed line represents observations made in 1985.



e If we assume that the expansion rate of this object has not changed since it first began to expand, estimate how long ago it started to expand.

f From the dates of observation and the units used on the graph, what sort of instrument made these measurements? _____

5 Team Name _____

Team Number _____

3 This is an image of one of our objects.

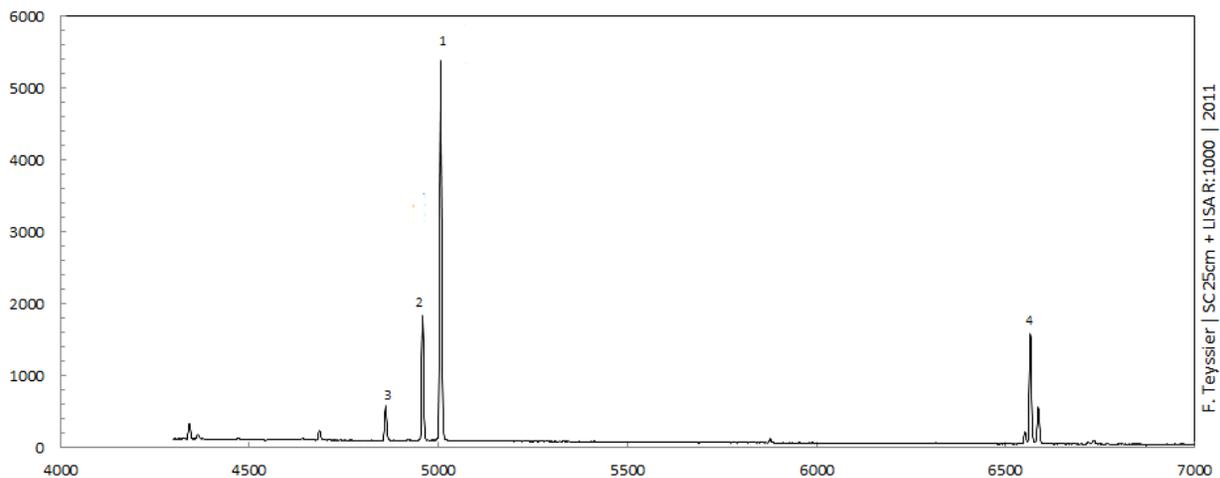


a Which of our objects is this? _____

b Which region/regions of the electromagnetic spectrum are represented in this image? Mark the box of the appropriate spectral regions. 1 point for each correct. -1 point for each incorrect region. Total score cannot go below Zero points.

Region	X-ray	UV	Visible	Infrared	Radio
Present					

This is a spectrum of this object taken by F. Teysier, a French amateur astronomer, in 2011.



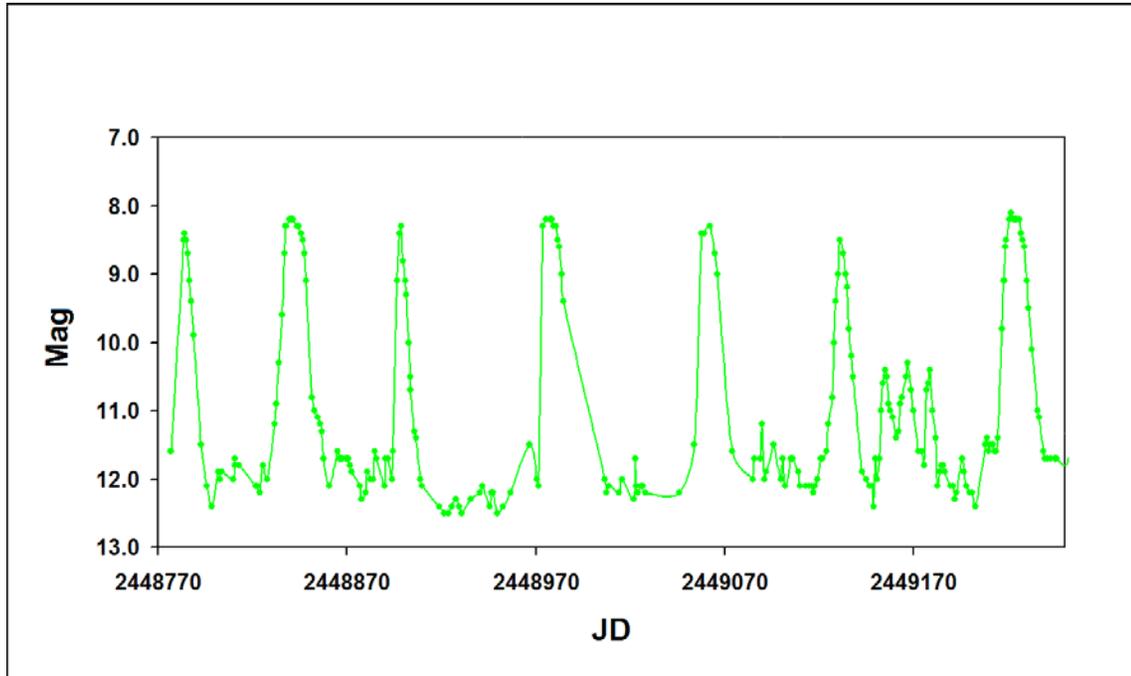
c What are the spectral features labeled 1, 2, 3, and 4 called? _____

d Fill in the table below with the element responsible for the labeled features above.

Feature	1	2	3	4
Element				

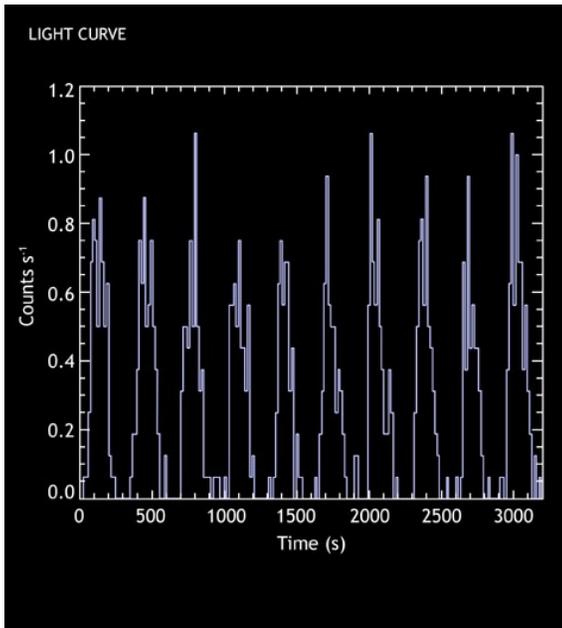
Total Points for this page _____

- 4 This is a light curve for one of our objects. It plots observations made nearby by Bob Modic. Bob is an amateur astronomer who lives in the area. This object is one of his favorites as it was the first object of this type that he noticed while looking for an entirely different object. These observations were done with his eye as the detector.



- a Which of our objects does this light curve represent? _____
- b What year or years were these observations made? _____
- c What sort of object is this? _____
- d Why is it possible to make observations of this object from this area without gaps in the sequence?

5 This is a light curve in X-ray radiation for one of our objects.



a Which of our objects is this? _____

b Use the information in the light curve to derive a period for this system.

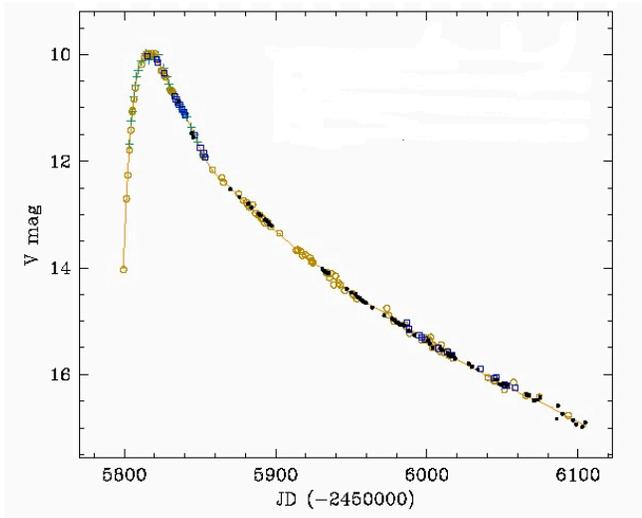
Assume that the this system consists of two objects that orbit each other in circular orbits, that the total mass of the system is $0.3 M_{\odot}$ (solar masses) and that the ratio of the mass of the larger to the smaller is 2:1.

c Find the separation of the center of masses of the two objects in au (astronomical units) using our assumptions and the period you derived in part b.

d Find the orbital velocity in km/sec of the higher mass component of this system.

e What is the source of the X-ray radiation that produced the light curve above?

6 This is the light curve of one of our objects.



a Which of our objects was observed to produce the data for this light curve?

b What is the nature of the event that produced this light curve?



c This image includes a view of our object. Circle our object in this image.

d Which region/regions of the electromagnetic spectrum are represented in this image? Mark the box of the appropriate spectral regions. 1 point for each correct. -1 point for each incorrect region. Total score cannot go below Zero points.

Region	X-ray	UV	Visible	Infrared	Radio
Present					

Total Points for this page _____

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e Use the data from the light curve above to calculate a distance to this object in Mpc (Megaparsecs).

f Use the distance you calculate in part e to get a radial velocity for this object.

7 Place the objects from problems 2, 3, 4, 5, and 6 in order of where they would fall on the evolutionary time-line of stars as they age.

Stage	First	Second	Third	Fourth	Fifth
Object #					

8 Which of the objects from problems 1-6 could be observed from Mentor, given a large enough telescope and some patience? Mark the "Observable" box for each of the objects that could be observed.

Object	1	2	3	4	5	6
Observable						

Total Points for this page _____