ASTRONOMY C

SSSS 2013 DSO List

While it is unlikely that a large number of these DSOs will show up on the actual 2013-2014 list, almost all are former DSOs or archetypes of variable star classes – and thus worth knowing.

Algol
Cygnus X-1
Delta Cephei
GK Persei
Mira
R Coronae Borealis
R Scuti
RR Lyrae
RX J0806.3+1527
Scorpius X-1
T Tauri
U Geminorum
U Scorpii
V838 Monocerotis
W Virginis
Z Andromedae

Directions (please read)

I. There is not a separate answer sheet. Write your answers on the test...or wherever you want, really.
II. For Part 3, SHOW YOUR WORK if you want anything that even remotely resembles partial credit.
III. Yes, significant figures do count.
IV. There is no penalty for guessing (except for possible ridicule from the person grading your test).

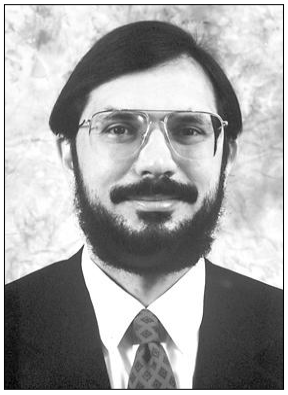
Use the values below when/if appropriate:

b = .0029 $m*K$
c = 2.998 $*\ 10^{8}\ m/s$
G = 6.674 $*\ 10^{-11}\ m^3/s^2/kg$
$H_0 = 70.\frac{km/_s}{Mpc}$
h = 6.626 $* 10^{-34}\ J*s$
k = 1.381 $* 10^{-23}\ J/K$
$\sigma = 5.670 * 10^{-8}\ \frac{W}{m^2K^4}$

$L_\odot = 3.839\ *\ 10^{26}\ J\ /\ sec$
$M_\odot = 1.989\ *\ 10^{30}\ kg$
$R_\odot = 6.960\ *\ 10^{8}\ m$
$T_\odot = 5800.\ K$

1 pc = 3.262 LY = 206 265 AU = 3.085 $*\ 10^{16}\ m$
1 LY = 0.307 pc = 63 240. AU = 9.46 $*\ 10^{15}\ m$
Absolute mag. of Type Ia SNe = –19.6

In the style of certain PA State Astro tests, name the two men pictured to the right for a bonus point.



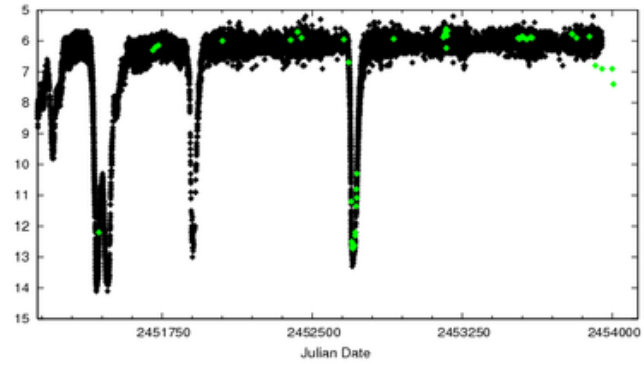
Part 1: DSOs & Variable Stars in General (54 pts)

1. Which DSO is leaving a comet-like trail of gas in its wake as it plows through the interstellar medium at 130 km/s?
    a. What is the approximate period of this DSO?
    b. This DSO and others of its variability class are passing through which phase of stellar evolution?
    c. The variability of this DSO is caused by the reversible synthesis of what chemical compound?
2. Which DSO is thought to consist of a pair of degenerate stellar remnants orbiting each other very quickly?
    a. What is the prototype for the very rare class of variable stars that this DSO belongs to?
    b. Why could this DSO potentially be used as a test of General Relativity?
3. Which DSO is a LMXB system with a 1.4 solar mass neutron star and a 0.42 solar mass star?
    a. What is the name of the visible component associated with this DSO?
    b. How does this DSO produce x-rays (explain briefly)?
4. Which DSO was discovered to be variable by John Goodricke in 1784?
    a. Why is this star a calibrator for the Period-Luminosity Relationship?
    b. What is an alternate name for the Period-Luminosity Relationship, named after one of its discoverers?
    c. What mechanism drives the pulsation of this type of variable stars (either name acceptable)?
5. Which DSO is noted for its sudden, unpredictable fading by several magnitudes?
    a. What process is responsible for this DSO's variability (explain briefly)?
    b. What are the spectral lines that characterize this DSO's variability class?
6. Which DSO is classified as type RVa by the GCVS (General Catalog of Variable Stars)?
    a. Which two other variability types (both prototypes are DSOs) may this DSO's class be a link between?
    b. What will be the end evolutionary state for most stars of this variable class?
7. Which DSO is sometimes classified as a LRN (Luminous Red Nova)?
    a. What is the <u>most likely</u> theory explaining this DSO's sudden outburst (explain briefly)?
    b. What is another theory explaining this DSO's sudden outburst (explain briefly)?
    c. If this DSO brightened from m = 11.5 to m = 6.5, by how many times did its luminosity increase?
8. Which DSO illuminates a nearby reflection nebula known as Hind's Variable Nebula?
    a. What is the name of the path that this DSO will follow across the H-R Diagram as it evolves?
    b. What is the main difference between Classic and Weak-Lined stars of this variability type?

9. Which DSO was discovered to be variable by J. R. Hind and N. R. Pogson in 1855?
    a. What are the three subclasses of this class of variable star?
    b. What is the main difference in the two competing theories explaining the process behind the outbursts?
10. Which DSO has a blue supergiant companion called HDE 226868?
    a. Why is this DSO referred to as a "microquasar"?
    b. Why is this DSO thought to have formed from a collapsar or a less-energetic supernova?
    c. This DSO was the subject of a famous bet between two famous astrophysicists – who won and who lost?
11. Which DSO is the prototype for the class of variable stars sometimes called "cluster variables"?
    a. How does the Blazhko effect affect this DSO and other variable stars of its class?
    b. What is the average absolute (visual) magnitude for this type of variable star?
12. Which DSO was first classified as a classical nova, then began to show signs of dwarf-nova-like variability?
    a. What is this DSO's classification in the GCVS (General Catalog of Variable Stars)?
    b. What feature of this DSO caused confusion due to apparent faster-than-light movement?
13. Which DSO is the prototype of symbiotic variables?
    a. What is unusual about the spectral lines shown by this DSO's variability class?
    b. What is the behavior of this DSO after it undergoes a large outburst, in terms of its light curve?
    c. P Cygni features occasionally appear in this DSO's spectrum – what do they look like, and what do they mean?
14. Which DSO is characterized by a light curve that shows a "bump" during its descent to minimum light?
    a. What are the subclasses of this type of variable, and what are these subdivisions based on?
    b. How did this class of variable stars help to resolve an astronomical puzzle concerning the Andromeda Galaxy?
15. Which DSO is capable of brightening from quiescence to maximum light in less than four hours during an outburst?
    a. Who was/were the first observer(s) of this DSO's most recent outburst?
    b. What is thought to be the difference between the progenitors of recurrent novae and classical novae?
16. Which DSO consists of a binary system of a B8V star and a K0IV star that complete an orbit every 2.87 days?
    a. How was the paradox associated with this DSO finally resolved?
    b. What is this DSO's variability type in the GCVS (General Catalog of Variable Stars)?
    c. Which star of this variability type has the longest period (hint: it is famous for a mid-minimum brightening)?

Part 2: Light Curves (16 pts)

Match each DSO with its light curve! (Hint: the scale on the bottom of each light curve may be helpful, though they are a bit hard to read.) There are 20 light curves, but only 16 DSOs – if a light curve does not belong to any DSO, leave it blank.



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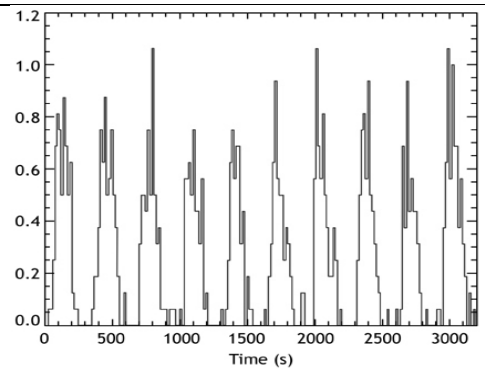

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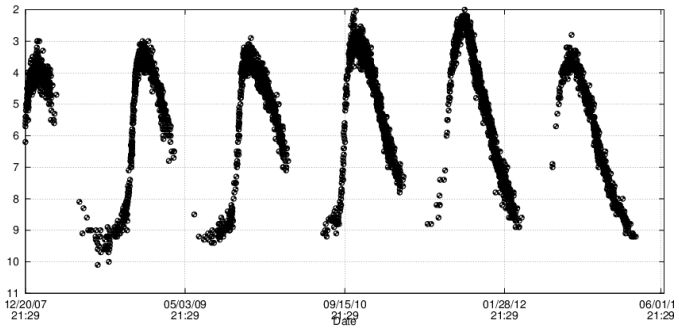

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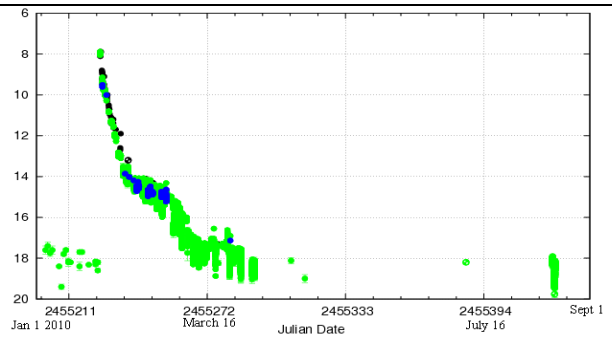

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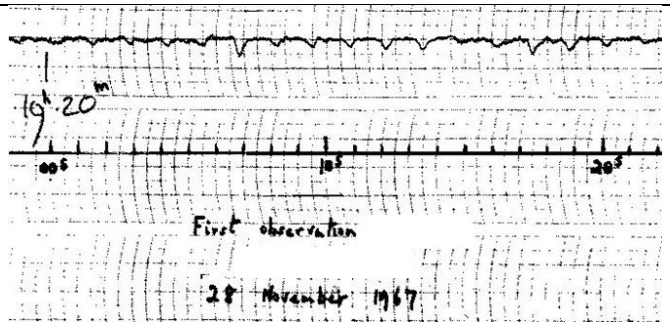

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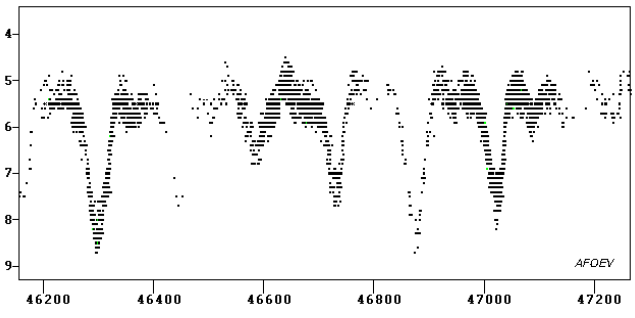

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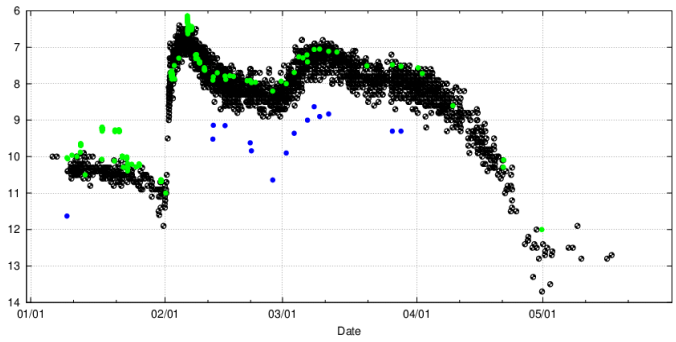
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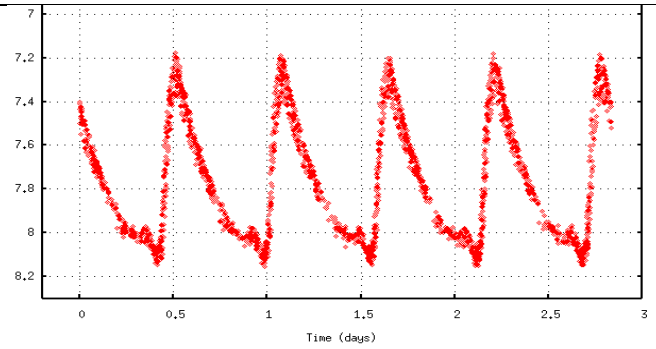
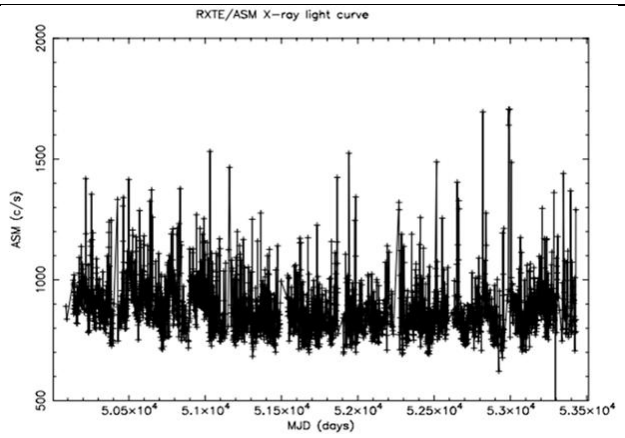
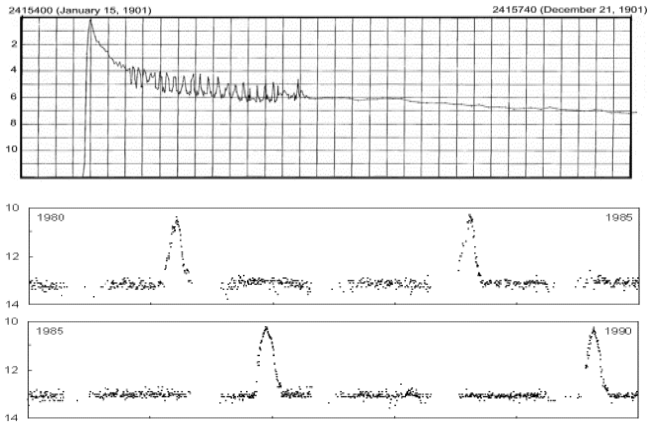
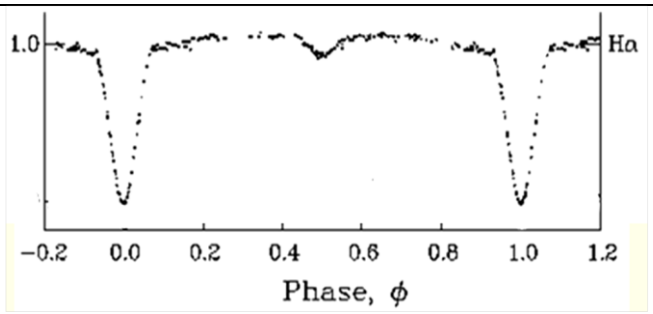
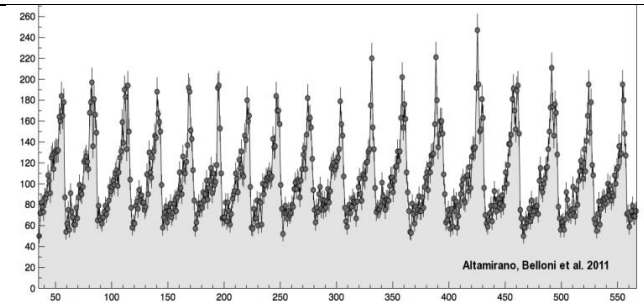
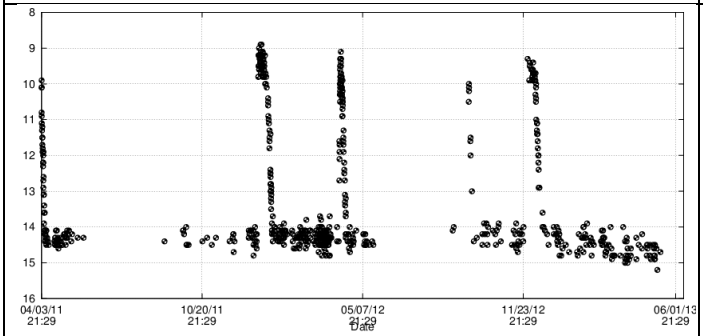

Time (days)


RXTE/ASM X-ray light curve
ASM (c/s)
MJD (days)


2415400 (January 15, 1901)
2415740 (December 21, 1901)
1980
1985
1985
1990


Hα
Phase, ϕ


Altamirano, Belloni et al. 2011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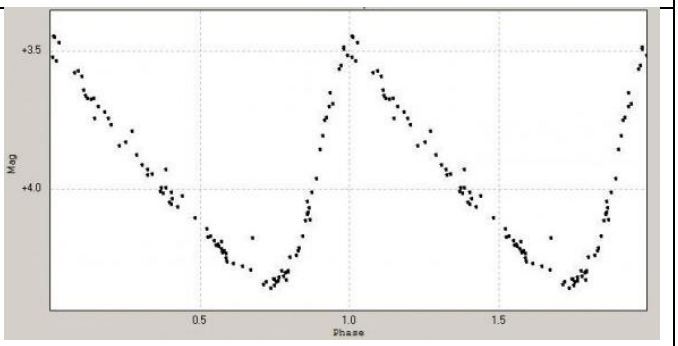
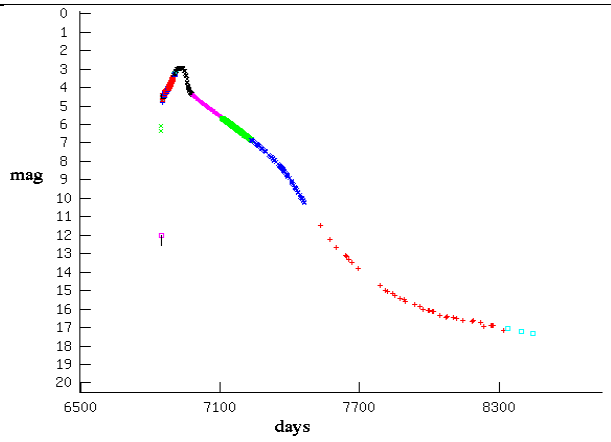

Mag
Phase


mag
days
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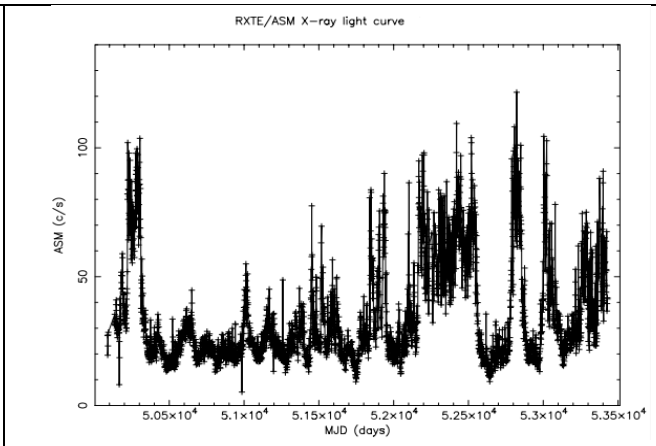
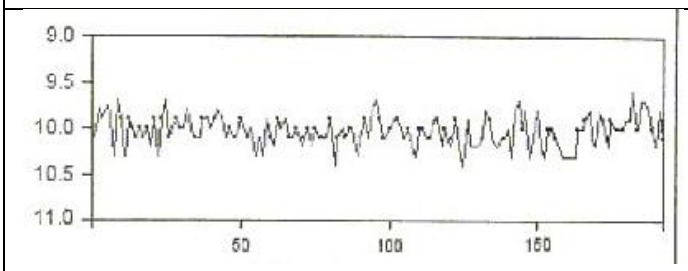
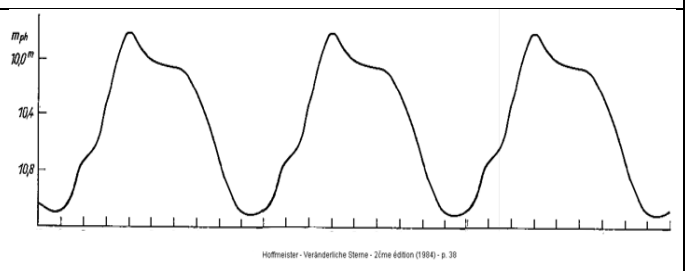
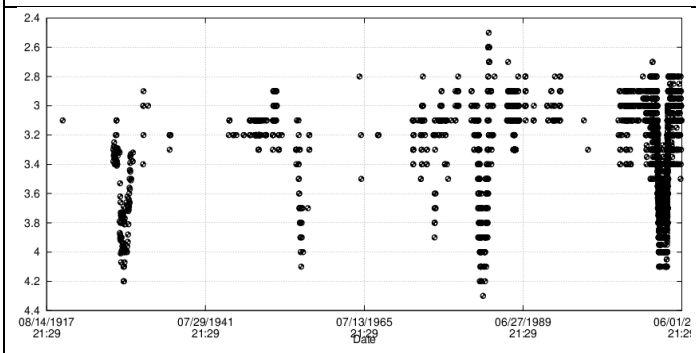
7100
7700
8300


RXTE/ASM X-ray light curve
ASM (c/s)
MJD (days)


9.0
9.5
10.0
10.5
11.0
50
100
150


mph
10,0m
10,4
10,8
Hoffmeister - Veränderliche Sterne - 2ème édition (1984) - p. 38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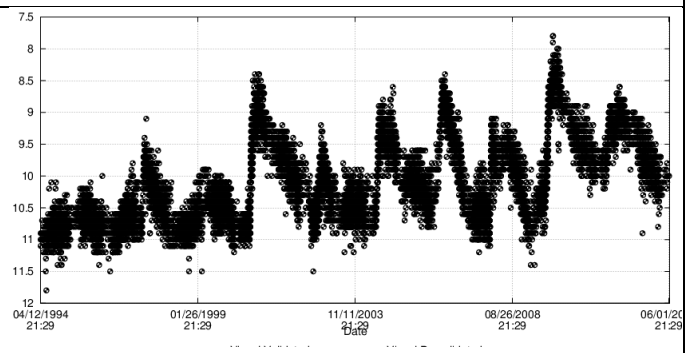

Date

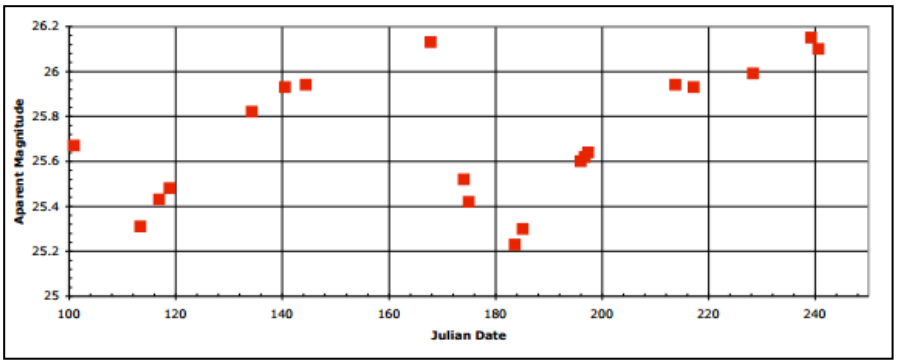
Part 3: Calculations (30 pts)

17. Star A and Star B form a binary system. The orbital period of the system is 236.3 days, and their mean separation is $8.835 * 10^9$ km. What is the total mass of the system, in kg? [3 pts]

18. In Star A's spectrum, the Lyman-α line is at most redshifted to 1215.71 Å. In Star B's spectrum, it is at most blueshifted to 1215.65 Å. Lyman-α normally has a wavelength of 1215.67 Å. What is the orbital velocity of each star, in km/s? [4 pts]

19. Based on your answers to the previous two questions, what are the masses of Star A and Star B? [3 pts]

20. The graph at right shows the apparent magnitude of a Type I Cepheid variable star. What is its period, to the nearest day? [1 pt]



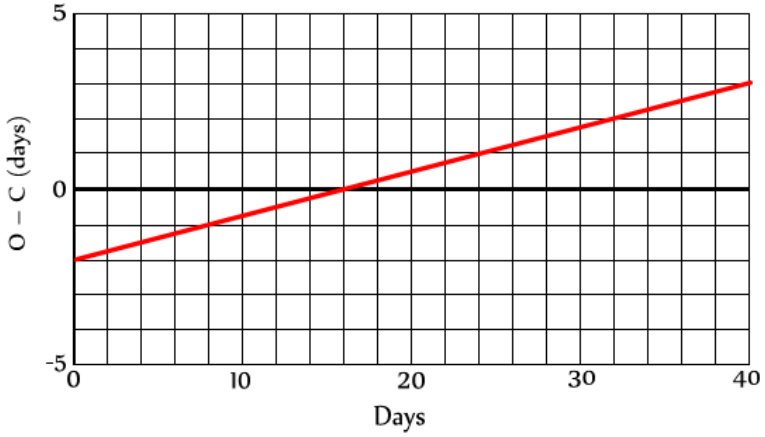
21. How far away is this Cepheid? [4 pts] (There is some leeway in the key, depending on the period used.)

Use the following equation for the Type I Cepheid Period-Luminosity Relationship: $M_{cepheid} = -1.43 - \left(2.81 * \log \frac{period}{1\,day}\right)$

22. A famous expanding supernova remnant is observed to have an angular diameter of 200. arcsec. This SNR is 407 years old and its apparent magnitude peaked at –2.25. Assuming the supernova was a normal Type Ia, what has been the average expansion velocity of the remnant, in km/s (use 1 year = 365.25 days)? [6 pts]

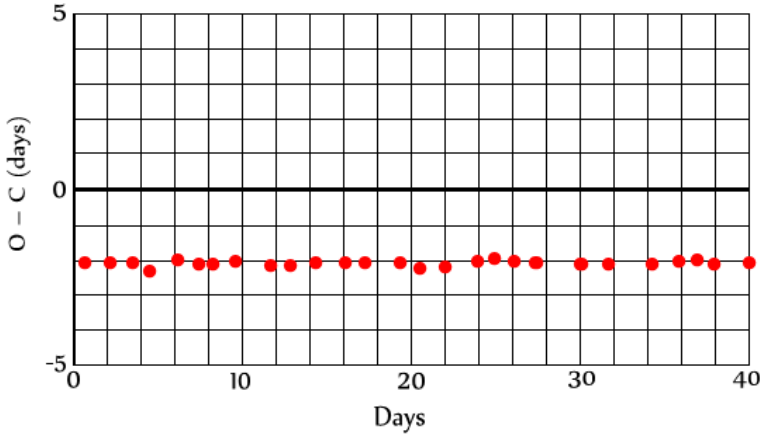
23. What kind of error does this O – C diagram indicate (i.e. what is wrong)? [1 pt]

24. Calculate said error. [1 pt]

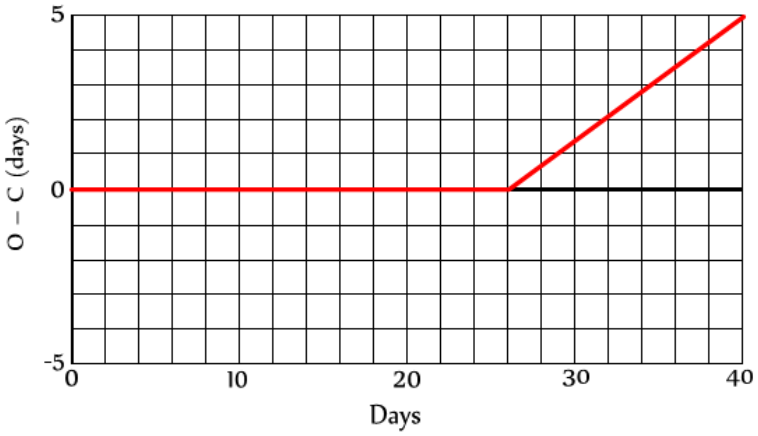


25. What kind of error does this O – C diagram indicate (i.e. what is wrong)? [1 pt]

26. Calculate said error. [1 pt]



27. What is the change in period shown in this O – C diagram? [2 pts]



28. Is the period increasing or decreasing? [1 pt]

29. What is the rate of change of the period? The equation for the parabola is $1/64\ x^2 - 1/2\ x + 1$, and the original period is 16 days. [2 pts]