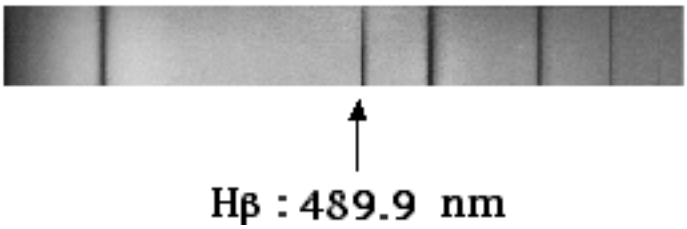
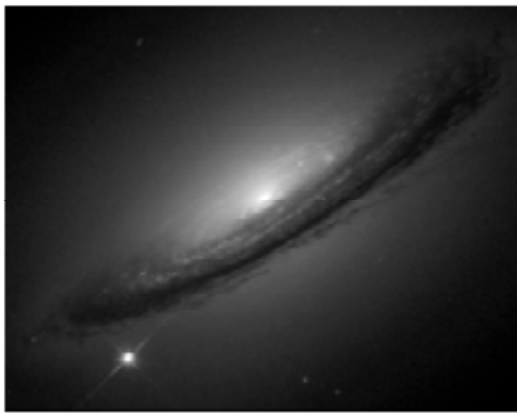
*The spectrum below is taken from the pictured galaxy*

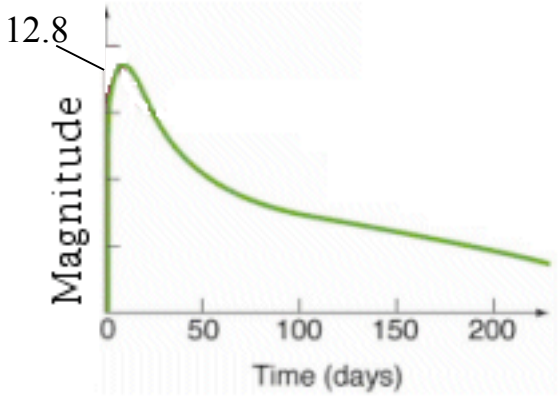


1. Is this galaxy moving toward or away from the observer? **(1 pt.)**

2. What is the magnitude of the galaxy's velocity? **(5 pts.)**

*A variable star with the light curve below is observed in this galaxy.*




3. What type of variable star is it? **(1 pt.)**

4. What is the maximum apparent magnitude of the variable star? **(1 pt.)**

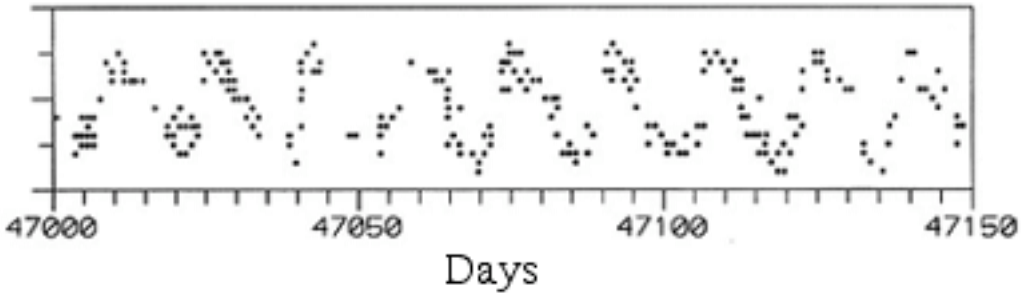
5. What is the average maximum absolute magnitude of variable stars of this type? **(1 pt.)**

6. What is the distance to this galaxy? **(4 pts.)**

**7.** Assuming that the universe is expanding at a constant rate, how far away would you expect to see a galaxy moving away from you at 500 km/s? **(7 pts.)**

8. Using the information above, what is the age of the universe? **(5 pts.)**

*You observe a cluster of stars containing a variable star with the following light curve.*




9. What type of variable star is it? **(1 pt.)**

10. What is this star's period **(1 pt.)**

11. What is this star's absolute magnitude? **(2 pts.)**

*This star's average apparent magnitude is equal to that of a main sequence F2 star, which is not a member of the cluster and which has a parallax of 0.0002 seconds of arc.*

12. What is the distance to this (the F2) star? **(2 pts.)**

13. What is the absolute magnitude of this (the F2) star? **(2 pt.)**

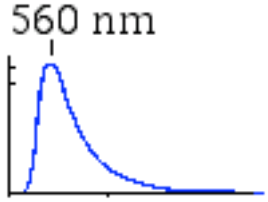
14. What is the apparent magnitude of these stars? **(4 pts.)**

15. What is the distance to the cluster? **(3 pts.)**

*The brightest main sequence star in the cluster has an absolute luminosity of 100 solar units.*

16. How old is the cluster? **(2 pts.)**

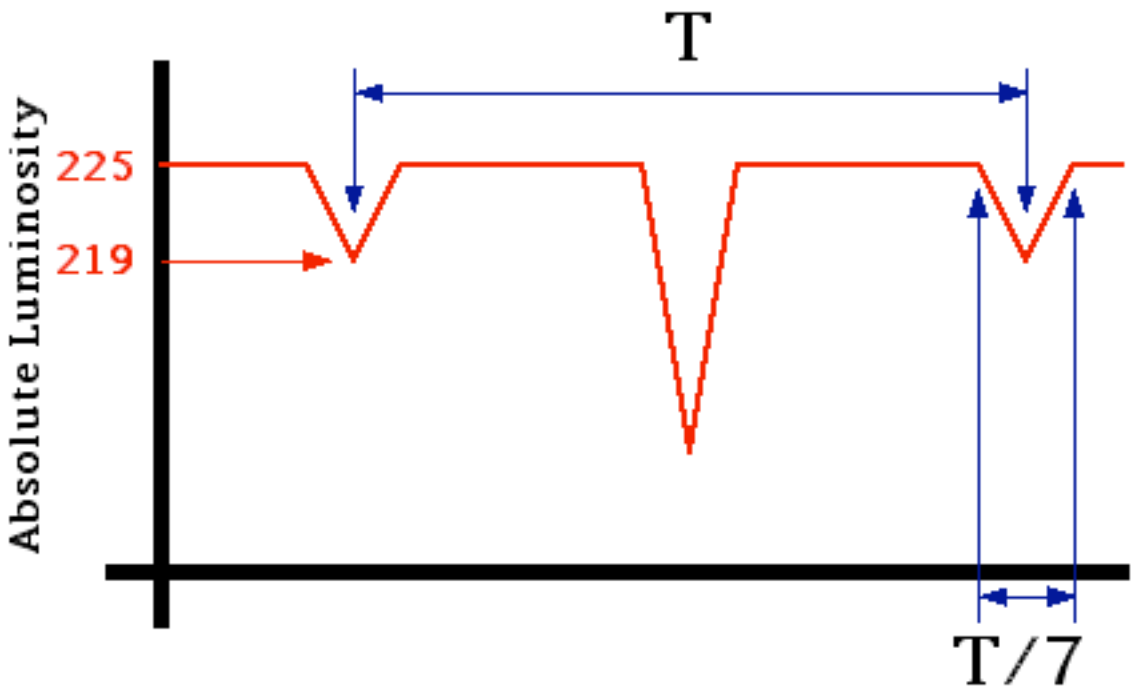
*Another main sequence star appears in the same field as the cluster and has the radiation curve below. It is also observed to have an apparent magnitude of 20.0.*




17. How far away is the star? **(10 pts.)**

18. Could it be part of the cluster? **(1 pts.)**

*A binary star system contains two main sequence stars. The orbit of the system is such that the brighter star completely occults the light of the dimmer. Below is a light curve produced by this system.*




19. What are the absolute luminosity and absolute magnitude of the dimmer star? **(2 pt.)**

20. What is the mass of the dimmer star? **(2 pt.)**

21. What are the absolute luminosity, absolute magnitude, and mass of the brighter star? **(3 pts.)**

22. What is the temperature of the brighter star? **(2 pts.)**

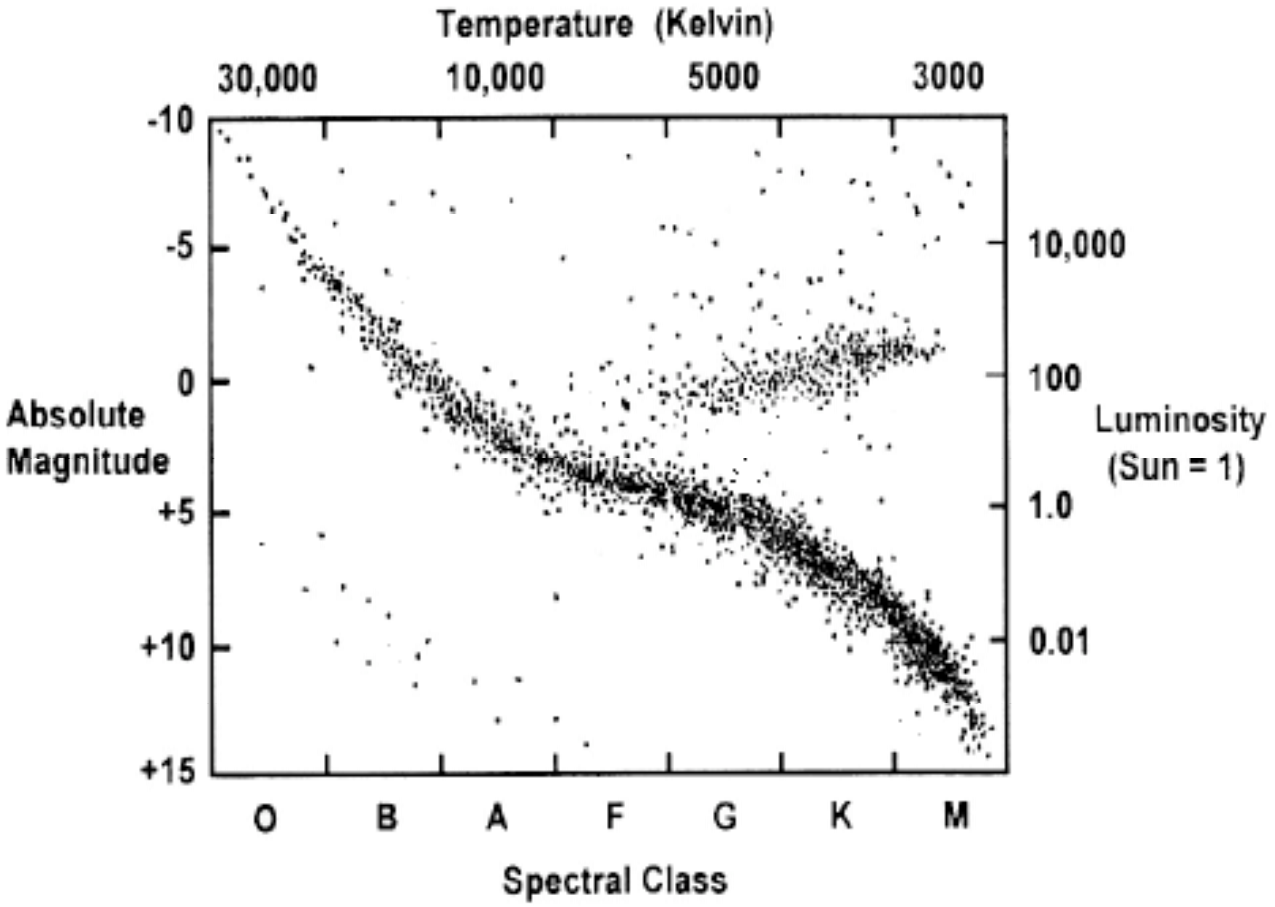
23. What is the radius of the brighter star? **(4 pts.)**

24. What is the separation of the system? **(10 pts.)**

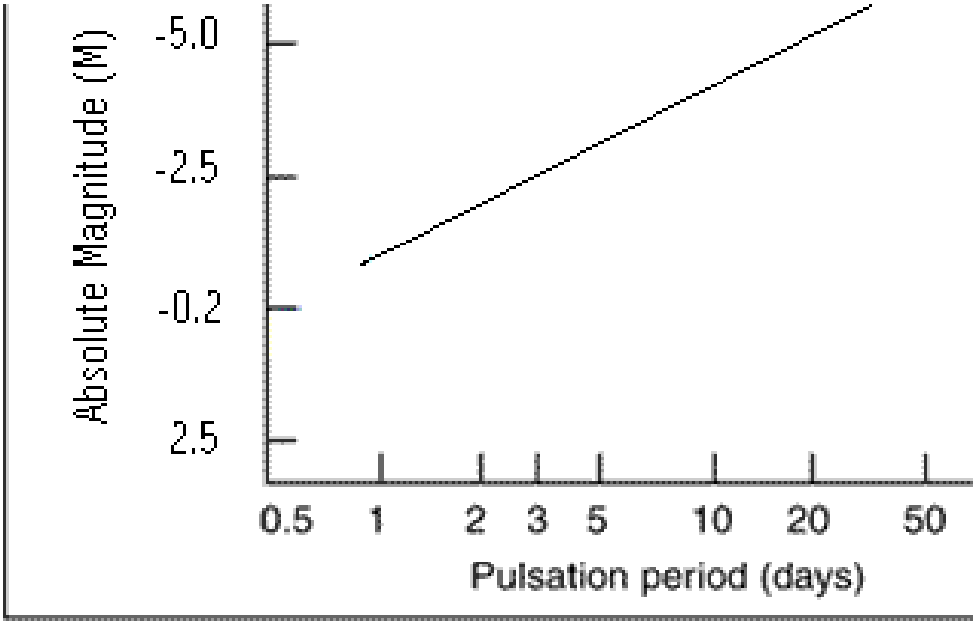
25. What is the period (T) of the system **(4 pts)**

*Appendices (To use in answering the previous questions)*

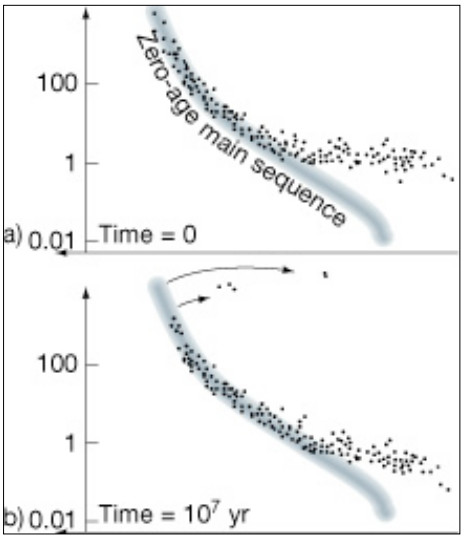
## Appendix 1:

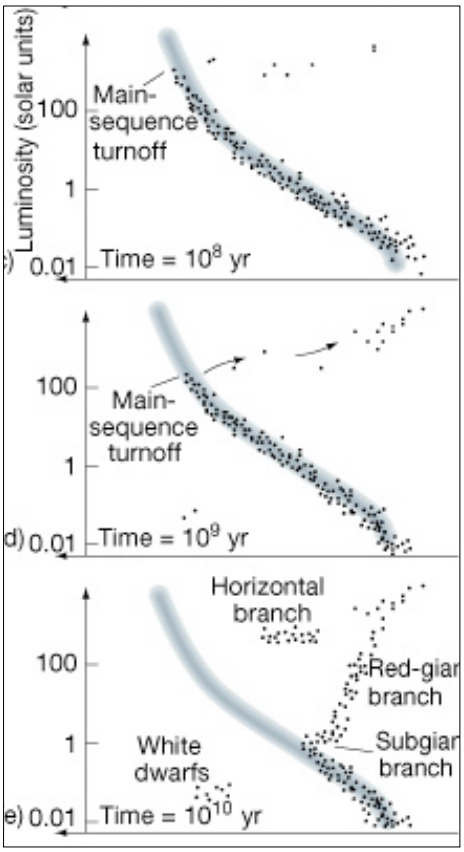



## Appendix 2:



Appendix 3:




Appendix 4:

| Type of Supernova | Maximum Absolute Magnitude |
|---|---|
| Type I Supernova | -19.9 |
| Type II Supernova | -20.25 |

Appendix 5:

| Main Sequence Stellar Mass Vs. Visual Magintude | | Absolute Magnitude | Stellar Mass |
|---|---|---|---|
| Absolute Magnitude | Stellar Mass | 1 | 1.98 |
| -4 | 8 | 1.5 | 1.8 |
| -3.5 | 6.8 | 2 | 1.65 |
| -3 | 5.8 | 2.5 | 1.51 |
| -2.5 | 4.95 | 3 | 1.4 |
| -2 | 4.24 | 3.5 | 1.3 |
| -1.5 | 3.65 | 4 | 1.17 |
| -1 | 3.17 | 4.5 | 1.07 |
| -0.5 | 2.78 | 5 | 0.97 |

## Appendix 6:

## Common Spectral Lines (given in angstroms)

| Hydrogen "Balmer series" | |
|---|---|
| H a | 6563 |
| H b | 4861 |
| H g | 4340 |
| H d | 4101 |
| H e | 3970 |
| **Helium** | |
| He I | 4026, 4388<br>4471, 7065 |
| He II | 4339, 4542, 4686 |
| **Molecular Bands** | |
| CH "G band" | 4300 |
| CN | 4215 |
| $C_2$ | 4697 |
| TiO | 4584, 4625<br>4670, 4760 |
| MgH | 4780 |
| **Telluric absorption bands** | |
| 5860–5990 | 6270–6370 |
| 6850–7400 | 7570–7700 |

| Metals | |
|---|---|
| C II | 4267 |
| C III | 4649, 5696 |
| C IV | 4658, 5805 |
| N III | 4097, 4634 |
| N IV | 4058, 7100 |
| N V | 4605 |
| O V | 5592 |
| Na I | 5890 |
| Mg II | 4481 |
| Si III | 4552 |
| Si IV | 4089 |
| Ca I | 4226 |
| Ca II | 3933, 3968 |
| Sc II | 4246 |
| Ti II | 4300, 4444 |
| Mn I | 4032 |
| Fe I | 4045, 4325 |
| Fe II | 4175, 4233 |
| Sr II | 4077, 4215 |