SPAC 201 TEST #1

Calculator allowed, closed Book, closed notes.

3/4/99 ; 75 minutes ; 1:00pm – 2:15pm

Be Concise: Long answers that are unclear will not get much credit. Label your variables, draw figures clearly, write clearly.

Don't Forget the Constants: If you need a constant look below, it might be there.

Do Not Panic: Give yourself a minute to think physically about the problem before you start to write. The exams will be graded on a curve.

Manage Your Time: Note that the problems do not all have equal weight.

Honor Pledge: You must include the honor pledge and your signature on the exam.

Useful Constants:

1 AU	=	1.495×10^{8} km
	=	1.495×10^{11} m
1 pc	=	3.09×10^{13} km
1 yr	=	3.15×10^{7} sec
1 radian	=	206265 arcseconds
$R_{\odot}$	=	6.96×10^{5} km
$M_{\odot}$	=	1.99×10^{30} kg
$R_{\oplus}$	=	6.37×10^{3} km
$M_{\oplus}$	=	5.98×10^{24} kg
R_{moon}	=	1.74×10^{3} km
M_{moon}	=	7.35×10^{22} kg
$L_{\odot}$	=	3.83×10^{26} W
σ	=	5.67×10^{-8} W m^{-2} K^{-4}
G	=	6.67×10^{-11} m^{3}kg^{-1}s^{-2}
h	=	6.626×10^{-34} J-s
c	=	3.00×10^{5} km s^{-1}
m_H	=	1.67×10^{-27} kg
Absolute Mag of $\odot$	=	4.75
$T_{eff}(\odot)$	=	5780 K

Part I: One-Line Answer (Answer 6 out of 7)
[6 pts; recommended time = 11 minutes]

1. List two advantages space-based telescopes have over ground-based telescopes.

2. What causes a nova?

3. Fusion occurs within the innermost ___% of the Sun.

4. Which two planets recently had a very close conjunction in the evening sky?

5. At the equinox the full moon appears directly overhead at local midnight. What is your latitude?

6. Why doesn't a He flash occur in the cores of massive stars?

7. List two types of observations that astronomers can use to learn about physical conditions beneath the visible surface of the Sun.

Part II: Short Answer/Calculation (Answer 4 out of 5)
[20 pts; recommended time = 37 minutes]

1. Imagine a star whose diameter is 10 times larger than that of the Sun and whose surface temperature is half that of the Sun. Suppose that both the Sun and this star were located at the same distance from you. Which would be brighter? By what factor?

2. What is the Doppler effect? Why is it important to astronomers?

3. The star Kruger 60B in the constellation Cepheus has an apparent magnitude of 11.3 and a parallax angle of 0.25 arcsecond. (a) Determine its absolute magnitude. (b) Give the approximate ratio of the luminosity of Kruger 60B to the Sun's luminosity.

4. What are the two distinct types of objects that become supernovae? Explain *briefly* why each blows up.

5. (a) Draw an HR diagram of a globular cluster and label the various portions of the diagram. Label your axes.

(b) Draw the HR diagram of the cluster as it will appear 5 billion years from now.

Part III: Derivation/Long Calculation:
Answer either #1 and #2, OR only #3
[14 pts; recommended time = 26 minutes]

1. Derive an expression for the lifetime τ of a star on the main sequence in terms of the stellar mass M and the solar main sequence lifetime $\tau_\odot$. You may use the mass-luminosity relationship discussed in class (if you don't remember this, you can guess something reasonable and get most of the credit). The lifetime of the Sun on the main-sequence is $\tau_\odot \sim 10^{10}$yr. Use your expression to find the main-sequence lifetime of a 2 $M_\odot$ star.

2. Derive Kepler's 3rd law,

$$\frac{R^3}{P^2} = \frac{GM}{4\pi^2} \tag{1}$$

for the case of a satellite of mass m moving around a planet of mass M. Take m << M and assume a circular orbit. Start with Newton's Law, F = ma = GMm/R^2, and use a = v^2/R for the acceleration. Then derive v^2/R with the use of the small angle approximation.

3. During the red giant phase the Sun will increase its luminosity by a factor of 2000. You plan ahead for this by purchasing real estate on Europa (available from your professor for a good price). Since Europa (a satellite of Jupiter, distance 5.2 AU from the Sun) has an icy surface, your plan is to develop a water resort where folks can float around on air mattresses as they watch the big red Sun rise and set.

Hmmmm, for this to work you need the temperature on Europa to lie between the freezing (273 K) and boiling (373 K) points of water. See if your idea works by calculating the temperature of Europa when the Sun is a red giant (**Hints:** Equate the total energy input per second from the Sun onto Europa with the thermal radiation emitted by Europa. It may be helpful to remember the units on flux, and make sure all your units balance).