

ASTRO 4: FINAL

YOUR NAME: _____

$L_{\odot} = 4 \times 10^{33}$ ergs/second $M_{\odot} = 2 \times 10^{33}$ grams Brightness $\propto 1/\text{distance}^2$ $c = 3 \times 10^{10}$ cm/sec.

Instructions: This was the final that was given in Winter 1998 for this class. You can use it as a mean to practice and review for our final (which will be shorter and easier!). Try to solve the exercises on your own and read the answers only after having done some work. Comments will be written in *italics*. It is useful to download the other quizzes and homework answer keys and see if you have a general idea of how to solve them.

1. **What time of day does the full moon rise?** a) at sunrise... b) \surd at sunset... c) at midnight... d) it can rise at different times depending on the time of year.

try to draw a little sketch

2. **Why do we experience day and night?** (choose one answer)

a) \surd because the Earth spins on its axis... b) because the Earth's axis is tilted... c) because the Sun orbits the Earth once every 24 hours... d) none of these.

the tilt of the orbit is important in explaining what important Earth cycle?

3. **What is a "light-year"?** A light year is a measure of distance; it is the distance covered by a ray of light traveling for one year. This is equal to the speed of light \times one year (remember, $d = v \times t$).

How many light years is a parsec?

4. **What kind of spectrum is emitted by a hot, low-density gas?** A hot, low-density gas emits an **emission spectrum** (no radiation at most wavelengths but a few, i.e. black background and a few bright colored lines). This is caused by electrons jumping from high-energy states to low-energy states.

What is wavelength? What is an absorption spectrum?

5. **In what ways does infrared radiation differ from radio waves?** Different wavelength, different frequency. See the handout 1 online.

6. **Suppose we give you the equation $\lambda \times f = c$ where λ stands for wavelength, " c " is the speed of light and " f " is frequency. Given a value of f for blue light, how would you calculate the wavelength of blue light?**

$$\lambda = \frac{c}{f}$$

7. **A 5500K solid object produces a continuous spectrum that peaks at around 5000 Angstrom (green light). Does it also produce infrared radiation?**

Yes! A glowing object (stars included) emit a **continuous** spectrum, called "Planck" spectrum; continuous means that it emits radiation at all wavelengths. The Planck spectrum has a peak at a characteristic wavelength given by **Wien's law**,

$$\lambda T = 0.29$$

(where λ is in cm).

Even though in this case the Planck curve peaks at green light, it is still giving off a little radiation in the infrared too, because it is a continuous spectrum.

8. **Suppose that we moved the Sun ten times further away than its current distance (be quantitative).**

a) How would the apparent brightness of the Sun change?
 The brightness is defined as

$$b = \frac{L}{d^2}$$

where L is the luminosity and d is the distance. Remember that the luminosity is an intrinsic property of the star, while brightness depends on how far the star is from you. (hold a candle near you, and then have someone hold it far away from you; the intrinsic luminosity has not changed, but its brightness has changed.). Since we moved the Sun 10 times as far, the brightness will become 1/100th of the original brightness.

what's the unit of energy?

b) How would the luminosity of the Sun change?
 It wouldn't. (why?)

9. **Compare the parallax angles of Stars A and B if Star A is twice as far from the Sun as B.**

The parallax angle is given by

$$\pi = \frac{1}{d}$$

(parallax: we see near stars “move” on the background of distant stars over the year. This is not a physical movement of the star, but is due to Earth's orbiting the Sun. It is the reason why holding your finger next to your eyes, and then opening one eye and then the other you see the finger “move”). *d* is the distance of the star and is measured in parsecs (3.26 light years). So, knowing that *d_A* is twice *d_B*, we can calculate π_A/π_B :

$$\frac{\pi_A}{\pi_B} = \frac{1/d_A}{1/d_B} = \frac{d_B}{d_A} = \frac{d_B}{2d_B} = \frac{1}{2}$$

so the parallactic angle of A is half the one of B. Does it make sense?

10. **Star A and Star B have identical spectra. If Star A is brighter than Star B, which of the following are true, which are false (assume no dust)?**

- Star A is more luminous than Star B
- Star A and Star B have the same temperature
- Star B is more distant than Star A
- Star A must be a giant

Spectral features are determined by temperature, so identical spectral features → equal temperature. Knowing only the brightness, you can't tell which of the stars is more luminous, or more distant.

11. **What is an eclipsing, double-lined spectroscopic binary and what information do we derive about stars by studying these binaries?**

*See lectures for a longer explanation; shortly, spectroscopic binaries are a couple of stars orbiting each other; when we look at their spectrum, their lines have periodic **blueshifts** and **redshifts** because they are moving in their orbits and so alternatively approach and recede from Earth. Try to draw a little sketch. What is the doppler effect?*

12. **For main-sequence stars in the Hertzsprung-Russell Diagram:**

a) Compare the luminosities of Star A and Star B if Star A has a higher surface temperature and twice the distance of Star B.

Draw the Hertzsprung-Russel diagram and the Main Sequence. Where are the most luminous stars? Where are the hottest stars? Where are the most massive?

b) Compare the masses of Star A and Star B from part (a). *See above.*

13. **A main-sequence star like the Sun radiates away an enormous amount of energy every second. Why doesn't all this energy loss cause the Sun to quickly cool off?**

___ because the Sun has such a large mass the cooling is hard to measure

___ the Sun is supported by e^- degeneracy and therefore its temperature doesn't change as it loses energy

✓ fusion in the core of the Sun generates exactly the amount of energy radiated away *what element is being burnt at the core of the Sun?*

___ The Sun *is* cooling off as it radiates and this is the reason it will become a red giant.

14. **What is the source of energy for main-sequence stars?**

a) electron degeneracy... b) ✓ mass converted to energy during hydrogen fusion... c) mass converted to energy during helium fusion... d) none of the above are correct

15. **What force holds the Sun together?**

a) Nuclear strong force... b) electrical force... c) ✓ gravity... d) Thermal force

16. **What is the main-sequence lifetime of a $2M_{\odot}$ star with $10L_{\odot}$ (the Sun’s lifetime is about 10 billion years)?**

The lifetime of a star depends on the ratio of its mass M and its luminosity L . You can compare it to the lifetime of the sun:

$$\frac{t_{MS}}{t_{\odot}} = \frac{M/L}{M_{\odot}/L_{\odot}} = \frac{M}{M_{\odot}} \times \frac{L_{\odot}}{L}$$

You will find the ratio of the lifetime of the star to the lifetime of the Sun. You can then multiply the ratio to the lifetime of the Sun in years to get the lifetime of your star in years.

What is the symbol \odot ?

17. **For up to 6 points, draw a Hertzsprung-Russell Diagram with properly labeled axes, indicate the main-sequence, red giant and white dwarf sequences and indicate the evolutionary track of a star like the Sun.**

18. **According to our best understanding of stars the Sun will eventually become which of the following objects?:**

red giant white dwarf neutron star *only high mass stars!* SN II *only high mass stars!*

19. **According to our current understanding, all the carbon and oxygen atoms in your body were manufactured in stars or supernovae explosions – True or False?**

Carbon was made by high mass and low mass stars that undergo $He \rightarrow C$ conversion; oxygen is made mainly by high-mass stars.

20. **What is an event horizon?**

The outer surface of the collapsed core of a massive star

the extent of the gravitational pull from a black hole

the boundary near a singularity inside of which the escape velocity exceeds the speed of light

all of the above are correct