Name: ....

ASTRONOMY 1102 – 1

Instructor: Juhan Frank

First Test – Friday February 12, 1999

Part I – Multiple Choice questions (5 pts/question; total = 60 pts)
Identify the correct answers by placing a check between the brackets [ ]. Check **ALL** correct answers in the questions identified by a *.

*1) The following are electromagnetic waves
[ ] sound.
[x] visible light.
[x] UV radiation.
[x] radio waves.
[ ] seismic waves.

2) The sequence of spectral types OBAFGKML is ordered according to
[ ] decreasing intensity of Balmer lines.
[x] decreasing surface temperature.
[ ] increasing depth of Hydrogen absorption lines.
[ ] increasing surface temperature.
[ ] increasing Hydrogen abundance.

3) The Hydrogen lines from a star moving with *negative* radial velocity
[x] appear blueshifted to shorter wavelengths.
[ ] appear blueshifted to longer wavelengths.
[ ] appear redshifted to shorter wavelengths.
[ ] appear redshifted to longer wavelengths.
[ ] appear at the same wavelengths as on Earth.

4) Fraunhofer lines are
[ ] emission lines in the spectra of stars.
[x] absorption lines in the solar spectrum.
[ ] emission lines from metallic elements.
[ ] absorption lines from the single element Hydrogen.
[ ] spectral lines caused by molecules.

5) The wavelength of UV (ultraviolet) radiation is
[ ] longer than 700 nm.
[ ] shorter than the wavelength of X-rays
[ ] longer than the wavelength of IR (infrared).
[ ] longer than 400 nm.
[x] shorter than the wavelength of any visible radiation.

6) A binary star is resolved (appears double through a telescope)
   [x] if it is a visual binary.
   [ ] if it is a spectroscopic binary.
   [ ] if the spectral lines redshift and blueshift periodically.
   [ ] it is an eclipsing binary.
   [ ] if we can measure the size of the stars.

7) The spectrum of a star with surface temperature T looks like
   [ ] a blackbody curve with the temperature T without any lines.
   [ ] a pure emission line spectrum.
   [x] a blackbody curve with the temperature T with absorption lines.
   [ ] a blackbody curve with the temperature T with emission lines.
   [ ] the spectrum of a low density gas at a temperature T.

8) According to the Stefan-Boltzmann Law, the energy emitted by a blackbody
   [ ] increases linearly with temperature $\propto T$.
   [ ] decreases in inverse proportion to the temperature $\propto 1/T$.
   [ ] increases as the square of the temperature $\propto T^2$.
   [x] increases as the fourth power of the temperature $\propto T^4$.
   [ ] does not depend on the temperature.

9) Hot solids, liquids and dense gases emit
   [ ] an emission line spectrum.
   [x] a continuous spectrum.
   [ ] an absorption line spectrum.
   [ ] visible light only.
   [ ] only infrared radiation.

10) A certain white dwarf has a parallax of 0.2 arcsec, so it is
   [ ] 1 pc away.
   [ ] 2 pc away.
   [ ] 3 pc away.
   [x] 5 pc away.
   [ ] 10 pc away.

11) The higher the frequency of electromagnetic radiation,
   [x] the shorter its wavelength.
   [ ] the longer its wavelength.
   [ ] the more it looks like UV radiation.
   [ ] the longer is the period of the waves.
   [ ] the faster it moves through space.

12) The lowest electronic energy state/level in an atom is the
   [ ] ionized state.
   [ ] first excited state/level and that is the normal state.
   [ ] second excited state/level.
   [x] ground state/level and that is the normal state.
   [ ] unstable state.

Part II – Problems (10 pts/problem; total = 40 pts) **NO CALCULATORS!**

Problem 1: A distant quasar moving *away* from us at a speed of $v = c/3$, where c is the speed of light, emits a spectral line whose true wavelength is $\lambda_{\rm true} = 300$ nm.

a) Do we see this line redshifted or blueshifted? Answer: *redshifted*

b) At what wavelength does this line appear to us?

$v = c/3$, *so* $\frac{\Delta\lambda}{\lambda_{\rm emi}} = \frac{1}{3}$

$\Delta\lambda = 300{\rm nm}\frac{1}{3} = 100{\rm nm}$

$\lambda_{\rm obs} = \lambda_{\rm emi} + 100{\rm nm} = 400{\rm nm}$

Problem 2: Two main sequence stars of the same size and surface temperature have the same luminosity. Star A is at a distance of 3 pc (parsecs), whereas star B is at 9 pc. Which will apear brighter and by how much (what factor)?

Star A is closer by a factor of 3, so it is brighter by a factor of $3^2 = 9$ *because of the inverse-square law*

$\lambda = cT \quad \lambda f = c \quad \frac{\Delta\lambda}{\lambda_{\rm emi}} = \frac{\lambda_{\rm obs} - \lambda_{\rm emi}}{\lambda_{\rm emi}} = \frac{v}{c} \quad \lambda_{\rm obs} = \lambda_{\rm emi} + \Delta\lambda$

$1 \text{ pc} = 3.2\ 6\text{LY} \quad d(\text{pc}) = 1/p(\text{arcsec}) \quad \lambda_{\max} \propto 1/T \quad E \propto T^4 \quad Flux \propto 1/d^2$

Problem 3: Two stars are at the *same* distance of 1.3 pc. Star A has a magnitude of +4, while star B has a magnitude of -1. a)Which *appears* brighter and by how much (what factor)?

B has the smaller magnitude, it is 5 magnitudes BRIGHTER than A. A difference of 5 magnitudes corresponds to a brightness ratio of 100. So B is 100 times brighter than A.

b) Which has the larger luminosity and by what factor? Justify.

Since they are at the same distance, their luminosities are in the same ratio as their apparent brightnesses. So B is 100 times more luminous than A.

Problem 4: You have at your disposal a good spectroscope, a very hot filament or some other source of energetic photons, and a low density cloud of Neon and a low density cloud of Helium (do not worry about how to contain these gases or what effect the walls of the container would have on the spectrum). Sketch below how you would arrange this equipment in order to see an *emission line spectrum of Neon.* Indicate where you place the different bits of equipment, label them clearly, and show which way the spectroscope is looking (You may or may not need everything listed above: in that case **list** what you are not using).

Place the cloud of Neon so that it is illuminated by the filament. The absorbed radiation will excite Neon atoms to excited states. As those atoms return to the ground level, the emission will occur at specific wavelegths. Looking at the cloud of Neon from any direction other than those that look through the cloud will produce an emission line spectrum.

NOT NEEDED: helium cloud.