Name: ....

ASTRONOMY 1102 – 1

Instructor: Juhan Frank

First Test – Friday February 12, 1998

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 waves cannot propagate through vacuum:
- [x] sound.
- [ ] IR radiation.
- [ ] radio waves.
- [x] seismic waves.
- [x] waves on the surface of a pond.

2) A main sequence star of type K5
- [ ] is hotter than the sun.
- [ ] is hotter than any white dwarf.
- [ ] is cooler than an M type star.
- [ ] is cooler than a K7 star.
- [x] is cooler than a main sequence star of type G2.

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

*4) The number of sunspots on the solar surface varies
- [ ] with an exact and constant period of 11 years.
- [x] with an average period of 11 years.
- [x] through two cycles during a complete magnetic cycle of the sun.
- [x] from one cycle to the next.
- [ ] with an average period of 6 years.

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

6) When the components of a binary star cover one another periodically as seen by us,
   [ ] we have a visual binary.
   [ ] we have a spectroscopic binary.
   [x] we have an eclipsing binary.
   [ ] we can determine the masses of the components.
   [ ] we see a redshift.

7) The spectrum of the sun looks like
   [x] a blackbody curve with $T \approx 6000$ K with absorption lines.
   [ ] a pure emission line spectrum.
   [ ] a blackbody curve with $T \approx 6000$ K without any lines.
   [ ] a blackbody curve with with emission lines.
   [ ] the spectrum of a low density gas at a temperature $T \approx 6000$ K.

8) Wien's displacement law: the wavelength of maximum blackbody emission
   [ ] increases linearly with temperature $\propto T$.
   [x] decreases in inverse proportion to the temperature $\propto 1/T$.
   [ ] increases as the square of the temperature $\propto T^2$.
   [ ] increases as the fourth power of the temperature $\propto T^4$.
   [ ] does not depend on the temperature.

9) A relatively cool gas in front of a hot and dense source of radiation produces
   [ ] an emission line spectrum.
   [ ] a continuous spectrum.
   [x] an absorption line spectrum.
   [ ] visible light only.
   [ ] only infrared radiation.

10) The parallax of a star 32.6 LY distant is *this 10 pc, so*
   [ ] 10 arcsec.
   [ ] 1 arcsec.
   [x] 0.1 arcsec.
   [ ] 0.01 arcsec
   [ ] 3 arcsec.

11) The lower the frequency of electromagnetic radiation,
   [ ] the shorter its wavelength.
   [x] the longer its wavelength.
   [ ] the more it looks like infrared radiation.
   [ ] the higher the energy of the photons.
   [ ] the slower it moves through space.

12) When an atom absorbs a photon, an electronic transition occurs
   [ ] in which an electron jumps to a lower energy level.
   [x] in which an electron jumps to a higher energy level.
   [ ] in which the atom vibrates faster.
   [ ] in which the atom rotates faster.
   [ ] which always ionizes the atom.

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

Problem 1: A neutron star binary ejects a luminous jet of matter moving *toward* us at a speed of $v = -0.1c$, where c is the speed of light. The gas in the jet emits a spectral line whose true wavelength is $\lambda_{\rm true} = 300$ nm.

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

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

$v = -0.1c$, *so* $\frac{\Delta\lambda}{\lambda_{\rm emi}} = -0.1$
$\Delta\lambda = 300\text{nm}(-0.1) = -30\text{nm}$
$\lambda_{\rm obs} = \lambda_{\rm emi} - 30\text{nm} = 270\text{nm}$

Problem 2: Two main sequence stars of the same size and surface temperature have the same luminosity. Star A is at a distance of 10 pc (parsecs), whereas star B is at 2 pc. Which will apear brighter and by how much (what factor)?

Star B is 5 times closer, therefore it is brighter by a factor of $5^2 = 25$ *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 17 pc. Star A has an absolute magnitude of 2 and star B has an absolute magnitude of 7. Which appears brighter and by how much (what factor)?

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

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 A is 100 times more luminous than B.

Problem 4: You have at your disposal a good spectroscope, a very hot filament, a low density cloud of Hydrogen 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 a spectrum that looks like a *Planck Curve*. 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).

A Planck Curve is the spectrum of a blackbody. A hot filament is a hot solid which by Kirchhoff's laws emits a continuum spectrum that resembles closely a blackbody. Place the spectroscope looking directly at the filament.

NOT NEEDED: hydrogen cloud, helium cloud.