PHY 261 PROBLEMS

2-D.1 Do Ex. 1.0 and complete the answer page.

2-D.2 Carefully use the Atlas of the Heavens (found in a drawer in the front desk of the astronomy lab) to identify what objects are located at the coordinates listed below. Also give the constellation in which these objects are found and what kind of object it is by using the key insert. Use the transparent coordinate overlay to assist you; use the Atlas on the front desk, not on the limited areas near a computer or you will damage the charts. Do not deface, damage or write anything on the charts. **Do not remove the Atlas from the lab room and do not lose the loose key insert or coordinate overlay that are in the front of the catalog:**

1. $\alpha = 7^h\ 15^m$; $\delta = +16^o\ 45'$,
2. $\alpha = 16^h\ 40^m$; $\delta = +36^o\ 45'$,
3. $\alpha = 19^h\ 42^m$; $\delta = -14^o\ 52'$,

3-C.1 Print the chart of the celestial sphere on the last page of Chapter 3 to submit for grading. For latitude 40^o N., find the NCP and SCP, draw the axis of rotation, the celestial equator, and the diurnal circle of the Sun on the days of the solstices and the equinoxes. Label everything you draw.

3-G.1. Find the zone time the Sun sets at latitude 40^o N. on the day of the winter solstice. The value of the equation of time may found from the graph in Chapter 3-G.

3-G.2. A more accurate determination of the time of sunset must take into account refraction caused by the Earth's atmosphere. Assume this is 1^o and recalculate the zone time the Sun sets at latitude 40^o N. on the day of the winter solstice.

3-G.3 Write a Fortran program that computes the zone time of sunset for input values of the latitude, the declination of the Sun, and the equation of time.

4-D.1 Precess the equatorial coordinates of Fomalhaut from 1950 to 2050, using the transformation equations given in Winkler, Am J. Phys., 40, 126 (1972).

5-C1**.** Run the *Planetmation* program in Skylab to determine the elongation of Venus on October 15 of this year and then use the above equation to compute what time Venus will set on this date. Submit a chart similar to Fig. 5-2 but showing the planets out to 2 AU, with a view-angle of 0^o (so that the view is perpendicular to the orbital planes) and draw the lines of sight and arc to indicate the elongation of Venus. Do the calculation in the upper right or left corner of the chart, whichever provides less interference with drawing the elongation.

5-D1. Trail Mars and then Jupiter separately in the SKYLAB program *Skymation* (not *planetmation*) to see these retrograde motions. Print out a separate chart for each planet and submit for credit. Start your trail in August 2011 for both planets. On the chart plot a grid and the stars. Also measure the elongation of each planet at the middle of the retrograde loop. You can use the reverse motion key to back up a planet in its orbit without ruining the trail to determine the date at the middle of the retrograde loop, which is the position labeled ***f*** in Fig. 5-4. Draw an arc on each chart for the elongation angle and label its value. This arc must be drawn along the ecliptic starting at the Sun and ending at the closest point to the planet.

5-E1: Trail Mars and then Mercury separately in the SKYLAB program *Skymation* to measure the length of their synodic and sidereal periods. Begin the trail on July 1 of this year. Print out a separate chart for each planet and each period and submit for credit. On each chart have SKYLAB plot a grid and the stars.

6-A1. Write a program that computes the position of Mars in its orbit in intervals of 10 days, starting at perihelion passage, t=0. Plot the results with Excel. Obtain all necessary parameters from:
nssdc.gsfc.nasa.gov/planetary/factsheet/**mars**fact.html.
Be careful when using the arc-cos function: the true anomaly must go from 0 to 360 degrees. Also be aware of when angles are radians and when they are degrees.
Normalize r to the perihelion distance in km, that is r=1 at perihelion, but you calculate by hand what the distance is in km. You have to figure out how to do this algebraically before you write your program and then incorporate the correct expression for r into your program.
Provide the following:

1. **A brief description (< 1 page, double spaced) of what you did and how you did it, including the derivation of the expression for normalizing r. This description should not be in programming, but in terms of the calculations.**
2. **A printout of your program with explanatory comments imbedded in the program.**
3. **Table 1 of input orbital parameters with units.**
4. **Table 2 of orbital coordinates t, r, upsilon, x, and y, with units. Tables must have column headers giving units and tables must be captioned.**
5. **A full page graph of x versus y with units and a caption. Make sure the x and y scales are the same or you won't see the proper shape of the orbit. Plot the data points as a scatter plot; do not connect the data points with a curve. Draw the major and minor axes of the ellipse and label them.**

6-C1: Use SKYLAB to find Ω for the planet Mars. You do this by trailing Mars in the SKYLAB program *Skymation*.

6-D1: Use the values for r and υ that you computed for Mars when t=40 days and calculate the x_2, y_2, z_2 heliocentric coordinates of the planet, that is, in the plane of the ecliptic with respect to the line of the nodes. Look up the necessary orbital parameters.

Chapter 7

7-B1: Write a program that numerically integrates P(v)dv from 0 to 2000 m/s for nitrogen gas at T = 100K and see how close this comes to being 1.00. Take dv to be 10 m/s.

7-B2: Starting with the Maxwell-Boltzmann velocity distribution function show that the most probable speed, v_p, is $(2kT/m)^{1/2}$.

7-C.1. What is the absolute temperature of a star that has its maximum monochromatic surface intensity at wavelength 2500 Angs.?

7-C.3 What is the monochromatic flux at a wavelength of 4860 Angs. that would be measured for a star with T=5000K, $R_* = 5.00R_\odot$, at a distance of 10.0 light years. $1\ R_\odot = 7.00 \times 10^{10}$ cm and 1 ly $= 9.50 \times 10^{17}$ cm.

7-E.1. a. Find the wavelength of the Lyman limit for hydrogen.
b. How many electronvolts would such a photon carry?

7-E.2. Find the wavelength limit for the Paschen series for hydrogen.

7-E.3. The ionization level for the ground state of neutral sodium atoms (Na I) is 5.138ev. Find the minimum speed of an electron that would just ionize Na I after a collision. What would be the temperature of an electron gas where this speed would be the most probable speed of an electron.

12. What is the absolute temperature of a star that has its maximum monochromatic surface intensity at wavelegth 2500 Angs.?

13. Derive Wien's Displacement Law from Planck's equation.

15. Write a FORTRAN program that computes the monochromatic surface flux of a star for a specific temperature, T. Then run the program in a loop that has the program yield values of the flux from 100 to 2000 nm in steps of 50 nm. These values are to be read into a two-column file of wavelength and flux for temperatures of 8000K and 3500K. Name the files as Toutput.txt files. Import the files into WORD to dress up and format the tables appropriately. Then import the files into a plotter such as EXCEL and plot the results on the same graph. Use a different symbol for the data points of each temperature and connect the points with a thin curve so that the data points can be seen. The graph must have a caption that explains what is displayed in the graph. Submit a copy of the program, tables of the output data and a graph of the data.

16. Modify the program written for problem No. 15 to integrate in a loop the area (integrated intensity units) under a Planckian curve between any two wavelengths. The integral is to be approximated by a finite sum of the areas in rectangles of height I_λ and base width, delta lambda. Then run the program using a value of delta lambda to be 5 nanometers from 10 nm to 1500 nm for temperatures 3500, 5000, 8000, 10000 and 15,000 K. Plot the results, integrated intensity versus temperature. Overplot on the same graph, the Stefan-Boltzmann Law for the same temperatures. Are the curves the same? Explain?

20. A star has a radial velocity towards an observer of 250 km/sec. What is the Doppler shift observed for the star for a spectral line that has a rest wavelength of 5500 Angstroms?

22. Use the spectrophotometric chart in Chapter 7-H.3 for a binary star at phase 0.742 to compute the radial velocities of the two stars at this orbital phase. Use the two spectral lines that are marked to indicate the Doppler shifted wavelengths of the lines, one for each star. Identify the blue shifted line to belong to Star 1 and then compute the velocities of Star 1 and Star 2.

The spectral line has a rest wavelength 3582.31Å. It will be necessary to use a centimeter ruler and measure accurately to obtain a chart scale and then determine the measured wavelengths of the two lines. To do this, print out the chart on which to make your measurements and submit this chart with your detailed calculations for the chart scale and the measurements to determine the wavelengths and Doppler shifts, as well as the computation of the radial velocities

Chapter 8

1. The ratio of the observed flux in the continuum to that at the bottom of an absorption line is 1.2. What is the optical depth of the atmosphere for radiation at the bottom of the line? (refer to my Chap. 8-2.1)

Chapter 11

1. Compute how many times the apparent brightness of the Sun is greater than the apparent brightness of the star Sirius (alpha Canis Majoris),when their apparent magnitudes are : m_{Sun} = -27.0 and m_{Sir} = -1.47.

2. Find the difference in magnitude for 2 stars that have a brightness ratio of 4.00.

3. Star A has a visible band flux, Fv = 4 x 10-3 erg/cm^2/sec, while star B has F_v =1.8x10-3 erg/cm^2/sec. If star A has m_v = 8.32, calculate the value of m_v for star B.

4. Calculate m_v for the Sun when observed from 65,000 AU, the outskirts of the solar system.

5. The parallax of alpha Centauri is 0.720 arcseconds and m_v = -0.01. Calculate M_V.

6. a. Find the distance modulus and absolute visual magnitude of a star that has an apparent visual magnitude of -0.4 and a parallax of p=0.30 arcseconds.
   b. What would the apparent visual magnitude of this star be if it were observed from a distance of 1 kiloparsec?

8. Given that the apparent visual magnitude of the Sun is -26.50,
   A. Calculate the absolute visual magnitude of the Sun.
   B. The parallax of alpha Centauri is 0.720 arcseconds. What would the apparent visual magnitude of the Sun be as seen from this star?

9. If the surface temperature of the Sun is 5800K and its radius is 7x10^5 km, what is the Sun's luminosity in watts?

Some of the following problems involve looking in the Appendices of Z&G to glean values for certain stellar parameters. In addition, the following are to be used:
The bolometric correction, BC, is defined by $M_{bol} = M_v - BC$;
Color excess, E, is $(B-V)_{obs} - (B-V)_{int}$;
The standard reddening law is A_v=3E, where A_v is the absorption in magnitudes for the V bandpass.

10. The star HD10911 has m_v = 6.05 and a distance of 1500 kiloparsecs. What is the value of $F_{V*}/F_{V_\odot}$?

11. A certain star has m_V = 8.30, m_B = 8.00, and a parallax of 0.002". The bolometric correction is -0.55 and its intrinsic B-V color index is -0.33.
   (a) Calculate M_{bol}
   (b) Find L_* / L_S.

Chapter 13

001. Use the spectroscopic parallax method to calculate the distance of star that has an apparent visual magnitude of 7.20, m_B =6.99 and a spectral class of B2 V. Assume the usual reddening law.

002. The star JG5 Oph is observed to have m_v = 4.74 and m_B = 5.93. The spectral class of the star is K0 V.
A. Find the color excess for this star.
B. Calculate the distance of the star by spectroscopic parallax. Assume the usual reddening law.
C. Find M_{bol}.
D. Calculate the luminosity of this in terms of the Sun's, i. e. $L_*/L_\odot$.

003. A star has a monochromatic surface intensity given by I_λ = A-Bsin(theta). Find the surface flux of the star.

004. The visual magnitudes of two stars are both 7.50, whereas the blue magnitudes are B_1 = 5.20 and B_2 = 8.7. Assume the two stars are both main sequence stars with no reddening.
(a) What is the B-V color magnitude of each star?
(b) Which is the hotter star?
(c) What is the ratio of their B fluxes.

Chapter 14

12. Calculate the main sequence lifetime of an O9 star with R=12.6$R_\odot$, T=31623K, and M=18.62$M_\odot$. Assume 0.10 of the star's mass is available for H fusion in the core.

22. A white dwarf with a mass equal to the Chandrasekar Limit has a uniform internal temperature of 5.00 x 10^7 K and a luminosity of 2.00 x $10^{-2}L_\odot$. Compute how long it would take for the star to cool to become a black dwarf with a uniform internal temperature of 500K. Assume the star consists entirely of C^{12} nuclei and neglect all the electrons.

The following are unassigned:

22. Find the ratio of the number of atoms in the first excited state to the number in the ground state for hydrogen in the atmosphere of a star at 10,000K.
23. Find the ratio of the strengths of the H_a emission to H_b emission lines for T=8000K. Neglect cascading transitions.
24. Find the number of H I atoms in the j=2 state (that is, N_{12}) for a gas at T=6000K.
Take the ratio of the number density of neutral atoms to ionized atoms ito be, N0/N+ = 0.05, the fractional hydrogen composition to be 0.75, m_H =1.67 x 10-24 gm, and the mass density, rho=2.0 x10^{-7} gm/cm3.
25. Calculate the partition function for H I at T = 6000K by. Take the ground state to be the zero level. Assume the probability for each energy level to be populated is 1.
(a) summing over only the ground state
(b) summing over the ground state and first excited states.
(c) summing over n=1 to n=3.
26. Calculate the number of H I atoms in the n=2 state for a gas with T=10,000K consisting of only H I atoms with a density of rho=1 x 10^{-7} gm/cm^3. Use m_H =1.67 x 10^{-24} gm.
27. Calculate the relative line strengths of Fe II to Fe I for an electron density, n_e=2.20x10^{14}, and T=9800K (Conditions found in the lower chromosphere for Sirius). Take $B_{Fe\ I}$ = 31.62, $B_{Fe\ II}$ =19.95, and X_{FeI} = 7.84 ev. Recall that line strengths depend on the number densities of the ions.
29. The photosphere of a star is said to be at an atmospheric optical depth =1. Compute the attenuation factor for radiation leaving the photosphere and emerging from the atomsphere. Assume the emissivity of the atmosphere is 0.

41. Calculate the thermal broadening for H-beta line for a temperature of 5800K. Assume the turbulence is zero. I got 0.16 Angstroms.
42. Calculate the width for the silicon spectral line at 1350 Angstroms produced by the atmosphere of a star with a surface temperature of 28,000K. Assume the turbulent velocity is 200 cm/sec. One atomic mass unit is 1.67x10^{-24} gm.

52. Calculate the central temperature of a star that has a mass of 2.5M_{sun}, a radius of 4R_{sun} and a chemical composition similar to that of the Sun.

61. How long will the Sun spend in the stage of He^4 burning in the core? Assume the core is entirely helium and is 0.09 of the present mass of the Sun and the luminosity is 100 the present L_{sun}.
62. What must be the temperature of a stellar core where the mean KE per nucleus would be equal to a coulombic barrier of 1 Mev.
63. Calculate the number of protons per cm^3 that have $E = E_c$ for the 1st step of the pp chain in an all H core of a star with $T=15 \times 10^6$K and a uniform density of 160 gm/cm3. Take dE to be $0.05E_c$.
64. Compute the rate of TNF energy generation with a layer of a star with r= 5E9 cm, Delta r=2E8cm, within which there is a constant density rho= 200 gm/cm^3 , X=0.5, for the pp chain, when
T=12E6K and $eps_0 = 1.80 \times 10^{-28}$ cgs units.
65. Calculate the luminosity of a star that results from hydrogen fusion by the pp chain if $eps_0 = 1.80 \times 10^{-28}$ cgs units. All reactions occur within $0.30R_*$, where $T=15 \times 10^6$ K and the mass density rho $=rho_c exp(-ar)$, where a = 3.05E-11 and R_* = 9E10 cm, rho_c= 160 gm/cm^3 , and X=0.70.