Answer 6 of the following 8 questions

Physical Constants:

$G = 6.6726 \times 10^{-11}\ \mathrm{m^3 \cdot kg^{-1} \cdot s^{-2}}$	$m_p = 1.6726 \times 10^{-27}$ kg
$h = 6.6261 \times 10^{-34}\ \mathrm{J \cdot s}$	$N_A = 6.0221 \times 10^{23}$
$k = 1.3807 \times 10^{-23}$ J/K	$L_\odot = 3.8460 \times 10^{26}$ W
$c = 2.9979 \times 10^{8}$ m/s	$M_\odot = 1.9889 \times 10^{30}$ kg
$e = 1.6022 \times 10^{-19}$ C	AU $= 1.4960 \times 10^{11}$ m

SJU observatory location: N 45°34′58”, W 94°23′25”

1. A detector is attached to a 1 m diameter space telescope and during a 600 second exposure 1000 photons are detected. The wavelength of each detected photon (in units of μm) is listed on the last page. (To aid you, I've sorted the list. Of course, they arrived in a random order.) Assume that the system is 100% efficient (i.e., every photon from the source that hits the telescope has its wavelength accurately recorded). Estimate the value of F_λ at $\lambda = .5\mu$m (include units!). The source is known to produce a blackbody (continuous) spectrum (so $F_\lambda(.5\mu m)$ is certainly not zero!). Estimate the temperature of this source.

2. Find the wall clock time when the star Deneb (R.A. $= 20^h41^m26^s$, DEC $=$ 45°16′49”) is on our meridian today (day number $D = 264$) at the SJU observatory. When Deneb crosses the meridian, what is its altitude?

3. In the movie *Star Wars N+1* our heroes are aboard the space ship *Millennium Falcon* in a circular orbit about the star Enoch. While outside fixing the warp drive, dopey robot C3P0 accidentally "drops" the warp engine. The scene shows the warp engine slowly drifting directly towards the star Enoch while C3P0 exclaims: "Help me R2D2! The warp engine is going to fall into the sun."

   Sketch the orbit of the *Falcon* and the trajectory of the warp engine. (Please exaggerate the difference between these orbits so that your diagram properly displays the small difference.) Compare (i.e., same, increased or decreased) the following quantities of the warp engine immediately before and after it is "pushed directly toward Enoch:" E (energy), L (angular momentum), a (semi-major axis), and e (eccentricity).

4. H_α (the lowest energy Balmer series line: $n = 2 \to n = 3$, with $\lambda = 656$ nm) is seen as an absorption line in the spectra of the Sun. Would you normally expect to see H_α absorption lines from hydrogen in the lab? Why? What conditions are required to observe this line in the lab? What should you do to see H_α emission lines in the lab?

5. <u>Derive</u> a formula giving the temperature of a fast-spinning planet in which, like Jupiter, "geothermal" heating is just as important as the heating from sunlight. Define a factor "g":

$$\text{total geothermal power released} = g \times \text{total solar power absorbed}$$

Your formula should include the distance the planet is from the Sun, r, the radius of the Sun, $R_\odot$, the temperature of the surface of the Sun, $T_\odot$, the albedo of the planet, a, and the blackbody fudge factor f. (Note: what to do with the area ratio is answered by the words "fast-spinning".)

6. Consider two stars: A (with magnitude $m_A = 1$) and B (with $m_B = 2$). What magnitude do they have together? If A's absolute magnitude is 4.74, what is the distance to A? If you learn that the temperature of A is twice the temperature of the Sun, how does A's radius compare to the Sun? (Note: the absolute magnitude of the Sun is also 4.74.)

7. We often use the ratio of F_ν at a "high" frequency (e.g., blue $= \nu_1$), $F_\nu(\nu_1) = F_1$ and at a "low" frequency (e.g., "visible" $= \nu_2$) $F_\nu(\nu_2) = F_2$ to determine the temperature, T, of a star. Write down a formula for F_1/F_2 if the star radiates as a blackbody at temperature T and sketch a graph of F_1/F_2 vs T. Carefully show/derive the behavior of the graph as $T \to \infty$ and $T \to 0$.

8. Sketch an HR diagram (label axes!) and approximately place the stars in the below table on that diagram. Answer the questions using the data in the table.

Star Name	Absolute Magnitude (M_V)	Apparent Magnitude (m_V)	Spectral Type	Luminosity Class
1. Canopus	-4.7	-0.7	F0	Ib
2. Wolf 359	16.7	13.5	M8	V
3. Gacrux	-2.5	1.6	M3	II
4. λ Ser	4.4	4.4	G0	V
5. El Nath	-1.1	1.7	B7	III
6. α UMa	-0.7	1.8	K0	III
7. α Aqr	-3.8	3.0	G2	I
8. Achernar	-2.5	0.5	B3	V
9. β Aqr	-3.5	2.9	G0	I

(a) Which star would look the brightest in the sky?
(b) Which star is the most similar to the Sun?
(c) Which star is intrinsically the brightest?
(d) Which star has the lowest surface temperature?
(e) Which star is furthest away?
(f) Which star has the largest radius?
(g) Which main sequence star has the largest mass?