Solve the problems listed below, and write up your answers clearly and completely. Do not turn in rough work – instead, make a clean copy after checking your calculations. Use English sentences and phrases to explain your solution and describe key equations. Show your work!

1. As seen from Earth, the Sun and the full Moon have apparent magnitudes of $m_\odot \simeq -26.7$ and $m_M \simeq -12.7$, respectively.
   (a) On Earth, the Sun’s flux is $F_\odot \simeq 1380 \text{ kg s}^{-3}$. What is the corresponding flux for the full Moon? Is “lunar power” likely to be a successful technology?
   (b) Imagine a star which has the same luminosity as the Sun and the same apparent magnitude as the Moon. How far away would it be?
   (c) Assume the disk of the Milky Way is composed of stars with the same luminosity as the Sun, and that the number density of these stars is $n = 0.15 \text{ pc}^{-3}$. Pretend that these stars are fixed in space, and that the Sun is moving through this distribution of stars at $v_\odot = 30 \text{ km s}^{-1}$. How often, on average, do we come close enough to another star for it to appear as bright as the full Moon?
   (d) In solving part (c), you can safely ignore the gravitational attraction between the Sun and other stars. Explain why this is true. (Hint: assuming an encounter velocity of $\sim 30 \text{ km s}^{-1}$, how closely would we have to approach the other star before gravitational effects became important?)

2. Consider a binary star system, in which star A has radius $R_A = 1.7 R_\odot$, effective temperature $T_A = 9900 \text{ K}$, and mass $M_A = 2.0 M_\odot$, and star B has radius $R_B = 0.9 R_\odot$, effective temperature $T_B = 5300 \text{ K}$, and mass $M_B = 0.9 M_\odot$. These two stars travel on circular orbits about their common center of mass, with a period $P = 40 \text{ day}$.
   (a) What is the orbital velocity of each star with respect to the center of mass?
   (b) Suppose we observe this system exactly edge-on to the orbital plane. Sketch the light curve over the entire $40 \text{ day}$ period.
   (c) Focus on what happens when star B passes in front of star A. Calculate (i) the total duration of the eclipse from start to finish, and (ii) the duration of the minimum brightness.
   (d) Suppose we observe this system with a detector which accurately measures total bolometric flux. By what fraction does the observed flux decrease (i) when star B passes in front of star A, and (ii) when star B passes behind star A?