UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Physical Astronomy (ASTR 391) — Prof. Crossfield — Spring 2026

Problem Set 3
Due: Monday, Feb 16, 2026 at the start of class
This problem set is worth **51 points** (+10 bonus).

As always, be sure to: show your work, circle your final answer, and use the appropriate number of significant figures.

1. **Stellar Types [24 pts]**
   (a) Devise your own mnemonic for remembering the stellar spectral sequence. [1/2 pt per spectral type]
   (b) Estimate the approximate stellar type and luminosity class for the three stars in PSet2, Question 2 (i.e., the giant star, the small star, and the hot star). [6 pts]
   (c) For the next three questions, consider two stars with different apparent brightness in the B and R photometric bandpasses. From your photometry, you correctly infer than star one is redder, and star two is bluer.
      i. Which star is hotter and which cooler? Explain. If one can't tell from the information given, describe what additional information you would need. [5 pts]
      ii. Which star is (intrinsically) brighter and which fainter? Explain. If one can't tell from the information given, describe what additional information you would need. [5 pts]
      iii. Which star is more massive and which less? Explain. If one can't tell from the information given, describe what additional information you would need. [5 pts]

2. **Angles & Distance in a Binary Star System [8 pts]**
   (a) You observe a binary star system (two stars orbiting each other) and from your observations you correctly infer that the stars are separated from each other by 100 au and are both 500 pc from the Earth. Draw appropriate diagrams to help you calculate: (i) What is the parallax to the binary system? (ii) What is the maximum angular separation of the two stars as viewed from Earth? [8 pts]

3. **A Circumbinary Planet [13 pts].** A star system has two similar stars orbiting each other; the orbit has an *apparent* (i.e., angular) semimajor axis of 2", and the parallax to the system is 100 mas (milli-arcsec).
   (a) Estimate the physical semimajor axis of the orbit in AU (draw a diagram!). [4 pts]
   (b) If the orbital period of the binary is estimated to be 100 yr, estimate the total mass in the binary and the approximate mass of each component, in $M_\odot$. What kind of stars are these likely to be? [5 pts]
   (c) The binary stars are discovered to host a circumbinary planet — i.e., a planet in a wide orbit going around both of the two stars — at an average angular separation from the binary of 20 arcsec on the sky. Assuming the planet is on a circular orbit, estimate the planet's semimajor axis in AU (draw a diagram!), orbital period in years, and orbital velocity in SI units. [4 pts]

4. **Order of Magnitude [6 pts]**. In SI units:
   (a) Estimate the luminosity of an ice cube.
   (b) Estimate the luminosity of your body.
   (c) Estimate the luminosity of the Earth.

5. **Bonus: Orbital Energy [10 pts]**. Assume a planet of mass m is in a circular orbit with semimajor axis a around a star of mass M_*.
   (a) What is the gravitational potential energy of this two-body binary system? [1 pt]

(b) What is the kinetic energy of the system in terms of the planet's orbital velocity v? [1 pt]

(c) Describe (or draw a diagram) indicating the direction and magnitude of the astronomically relevant forces acting on the planet. Remember, things like 'centripetal forces' aren't real *physical* forces – they're essentially just (useful!) descriptions of motion. [2 pts]

(d) Using Newton's Second Law, derive an expression for the planet's orbital velocity v^2 in terms of the other quantities given. [3 pts]

(e) Write an expression for the total energy in the system in terms of m, M_*, and a but not v. Simplify your answer as much as possible. [3 pts]