UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Astrophysics I (ASTR 691) — Prof. Crossfield — Fall 2026

In-Class Problems 17 [23 pts]
You may use your OoMA Sheet, your handwritten notes, and a scientific or graphing calculator – and you may work in a group. As always, be sure to: show your work, circle or highlight your final answer, list units, use the appropriate number of significant figures, and write your name.

1. **Brightness Temperatures [14 pts]**

   (a) (5 pts) Calculate the surface flux density of an object emitting as a blackbody, (i.e., $F_{\lambda,\mathrm{surf}} = \pi B_\lambda$), at a wavelength of 4.5 μm and with temperatures of 300 K, 1000 K, and 3000 K. Give your answers in units of W/m^2/μm.

   (b) (3 pts) Assume that the objects above are Brown Dwarfs: the size of Jupiter, and 10 pc away. Calculate the observed F_λ for each of the three temperatures above.

   (c) (3 pts) Using JWST, you observe a brown dwarf 10 pc away and measure a flux density of 3×10^{-15} W/m^2/μm. Assuming it is the size of Jupiter, what is its surface flux density?

   (d) (3 pts) What must the surface temperature of this brown dwarf be, in order to explain your observed flux density?

2. **A New Dwarf Planet.** In October 2026 a new dwarf planet, named 2026 ED138, was discovered using data from the new Rubin Observatory (see e.g. `https://arxiv.org/abs/2611.02371`). [9 pts]

   (a) What is the equilibrium temperature of 2026 ED138, in terms of its orbital semimajor axis a and the solar radius and temperature $R_\odot$ and $T_\odot$? [2 pts]

   (b) How would the equilibrium temperature of 2026 ED138 compare to that of an identical dwarf planet, orbiting an M dwarf with size and temperature roughly half that of the Sun? [2 pts]

   (c) How does the equilibrium temperature of 2026 ED138 compare to that of an otherwise-identical dwarf planet, orbiting the Sun on an orbit just 1/15$^{\mathrm{th}}$ sa wide (such as Ceres) ? [2 pts]

   (d) Calculate the equilibrium temperatures of the three cases given above, in K. [3 pts]