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

In-Class Problems 8 [28 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. **Photon Energies [7 pts]** Calculate the energy (in eV) of a photon at each of the following wavelengths:
   (a) 1 nm (X-ray, accessible to Chandra)
   (b) 1200 Å(UV, roughly the shortest accessible to HST)
   (c) 500 nm (V-band optical)
   (d) 2 μm (K-band near-infrared)
   (e) 25 μm (the longest accessible to JWST)
   (f) 1 mm (e.g., ALMA)
   (g) 1 m (e.g., VLA)
2. **Kirchhoff's Laws of Spectroscopy [6 pts]** Explain each of Kirchhoff's three laws of spectroscopy. Use the equation of radiative transfer (and its general solution) to explain each of the three laws.
3. **Yet More Radiative Transfer [15 pts]**. Qualitatively describe what kind of spectrum you would expect to observe in each of the following situations? Explain why, and roughly sketch a representative example spectrum describing what you mean.
   (a) A hot, tenuous, diffuse planetary nebula.
   (b) A bright, distant quasar observed through intervening clouds of cold hydrogen.
   (c) A sun-like star.
   (d) A planet with an atmosphere hotter than its surface.
   (e) A planet with no atmosphere.