

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

In-Class Problems 3

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. How Do You Say “Absorption” in Astrophysics? [12 pts]

- (a) Define α_λ , extinction coefficient (in words, not just an equation!), and give its typical units. [3 pts]
- (b) Define σ_λ , cross-section (in words, not just an equation!), and give its typical units. [3 pts]
- (c) Define κ_λ , opacity (in words, not just an equation!), and give its typical units. [3 pts]
- (d) Define τ_λ , the optical depth (in words, not just an equation!), and give its typical units. [3 pts]

2. A Hazy Morning [15 pts] On a given day the weather report mentions that visibility is roughly D (measured in meters). Take that as the distance at which $\tau_\lambda \approx 1$:

- (a) Estimate the atmosphere’s extinction coefficient α_λ that morning. [3 pts]
- (b) If the visibility is mainly limited by smoke from nearby fires, estimate the number density n of these particles in the atmosphere. (Assume a typical smoke particle has a size r). [4 pts]
- (c) Given the typical density ρ of air at sea level, estimate the opacity κ_λ of the smoky air (in SI units). [4 pts]
- (d) Now assume that this same smoke layer is confined to a thin layer near the ground with a thickness of just H (due to some unknown atmospheric phenomenon; the reason isn’t important here). What is the optical depth at visible wavelengths when looking straight overhead? and when looking up at a 45° angle (halfway between straight up and parallel to the ground)? [4 pts]