

Physical Meteorology
ATMS 455 – Spring 2025
Study Guide for Exam I

So far this semester, we've studied the composition and thermodynamics of the atmosphere, aspects of the acceleration of gravity, lapse rates, the electromagnetic spectrum, terrestrial refraction, mirages, astronomical refraction, and rainbows. To create the exam, I will peruse the class notes and handouts and pick out some important topics, so that would be a great way to study. The following list is not exhaustive, but should give you an idea of the topics that the exam will cover. The questions will be in short-answer and fill-in-the-blank format. This is a **closed-book** exam and you will not receive a list of equations, so you should memorize or be able to derive simple relationships. It would be a very good idea to review the homework assignments, handouts, and class notes. Your goal (and my goal for you) is to understand the *concepts* from the course. The exam will take place in person in RRO 238 on **Monday, 24 February 2025 at 11:00 a.m.** As always, ask questions and good luck!

1. You should have received the following handouts in class: *Problem Set Tips and Expectations, Atmospheric Composition, Vertical Structure of the Atmosphere to 100 km, Atmospheric Properties, Atmospheric Structure, Lapse Rates, Traveling Waves, Terrestrial Refraction, The Inverted Inferior Mirage, Astronomical Refraction, Rainbow Geometry, Rainbow Intensity.*
2. What are the major atmospheric gas constituents and what are their concentrations?
3. Name several trace constituents of the atmosphere. What are some gases with variable concentrations? What else is up there?
4. What are the layers of the atmosphere? How are they defined?
5. Why are ozone and water vapor important?
6. What and where is the ionosphere, where are its layers located, and what is each layer called?
7. How does the concentration of ozone vary with height?
8. What is the difference between molecular and kinetic temperature?
9. What is the molecular weight of dry air at sea level?
10. What two components contribute to the measured acceleration of gravity at sea level?
11. How does the height of a pressure surface depend on the temperature of an atmospheric layer?
12. What is the scale height and how is it defined?
13. What are the homogeneous and dry adiabatic lapse rates and how are they defined?
14. Understand how pressure, temperature, and density vary with height in a layer with a constant lapse rate.
15. What two accelerations are in balance when an object is in orbit?
16. What is a geosynchronous orbit?
17. What is primarily responsible for atmospheric tides?
18. What are the types of electromagnetic radiation? What are some representative frequencies and wavelengths for each type? How are these related to the propagation speed of the wave?
19. What is the angular wave number? What does it mean?
20. How is the index of refraction defined? How does light change direction when moving from one medium to another? What about through multiple media? What happens to the frequency of the wave? What happens to the wavelength?
21. What is Snell's law? You might want to memorize it and know how to apply it.
22. Why is the index of refraction for microwaves a function of temperature?
23. What happens to the speed of light as a function of height under normal lapse conditions?
24. How is the curvature of a light ray related to the lapse rate? You might want to memorize the meat and potatoes of this general relationship.
25. How does refraction extend the distance to the apparent horizon?
26. Understand how the following phenomena occur: superior and inferior mirages, looming, sinking, stooping, towering, and multi-part mirages. Be able to identify the type of mirage associated with a particular temperature profile and vice versa.
27. What is astronomical refraction and how does it influence astronomical observations, sunrises and sunsets?
28. How does the refractive index change with the wavelength of light?
29. What is the minimum deviation angle and how does it influence optical phenomena? What is special about this angle?
30. Describe the physical processes involved in the production of rainbows.
31. What is Alexander's dark band? What are supernumerary rainbows?
32. Why are primary rainbows brighter than secondary rainbows? Why is it difficult to see tertiary rainbows?
33. Derive the rotation rate of the Earth (i.e., Ω).