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

Since the last exam, we've studied ice crystal phenomena, diffraction, scattering, and radiation principles. As with the last exam, I will create questions by perusing the class notes and handouts to 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 again 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 during the regular class time (11:00–12:15 p.m.) on Wednesday, 9 April 2025.** As always, ask questions and good luck!

1. You should have received the following handouts in class since the last exam: *Halo Phenomena, Table 3-1, Refraction of Light by Ice Crystals, Diffraction Phenomena, Scattering Processes in the Atmosphere, Spectral Distribution of Blackbody Radiation, The Sun and the Solar Spectrum, Absorption Spectra, Earth–Sun Geometry, Daily Solar Insolation at the Top of the Atmosphere, The Global Energy Balance*
2. What is the value of the Stefan-Boltzmann constant? What are the units?
3. Describe the physical processes involved in the production of rainbows, ice crystal phenomena, and diffraction phenomena.
4. Exactly why is the sky blue? What is the *full* name of the phenomenon responsible?
5. How does the prism angle influence ice crystal phenomena? Which types of crystals and which orientations produce which phenomena?
6. Why are sundogs next to the Sun? Why are they not exactly on the 22° halo?
7. What is diffraction? What is the difference between Fraunhofer and Fresnel diffraction?
8. What does Huygen's principle say?
9. What does Babinet's principle say? What does this have to do with atmospheric optics?
10. What is the significance of the first-order Bessel function in diffraction phenomena?
11. How do droplet sizes influence the angular radii of rings in a corona?
12. List some ice crystal (refraction), diffraction, and reflection phenomena. Describe each phenomenon that we studied in class.
13. How does the size of an atmospheric particle affect light scattering? What size particles are responsible for Lorenz-Mie scattering? Do these particles have common names?
14. Why isn't the sky violet?
15. What is the difference between flux, irradiance, radiance, flux density, intensity, and luminosity? What are the units of each?
16. What does *monochromatic* mean? Why do we care?
17. What is a solid angle and what are its units?
18. What are reflectivity, absorptivity, and transmissivity and how are they related?
19. What is a blackbody?
20. What does Kirchhoff's law say?
21. What is the energy of a photon?
22. What is Planck's function and what can we use it for? How does it change with temperature?
23. What is the Stefan-Boltzmann law and how can we apply it? What does it mean physically?
24. What is Wien's displacement law and how can we apply it? How does it relate to Planck's function?
25. What is emissivity?
26. What is the solar constant (both numerically and physically)? How constant is it?
27. Understand how to calculate the solar flux (a constant), the solar irradiance, the effective blackbody temperature of an object, and the intercepted flux of a planetary object.
28. What is the Earth's average albedo and how is it defined? What is the albedo for certain objects (e.g., clouds, snow/ice, water, land, etc.)?
29. *Derive* an equation for the Earth's radiative equilibrium temperature based on the Earth's budget of incoming shortwave and outgoing longwave radiation. Derive a similar relationship for any object, regardless of its shape.
30. What are the major selective absorbers in the Earth's atmosphere?
31. What types of energy transitions are responsible for absorption lines in various parts of the electromagnetic spectrum? Which three energy transitions are possible? Which types of molecules are responsible for this absorption?
32. What is the atmosphere's optical depth and what does it have to do with the atmosphere's absorptivity? How is absorptivity different from scattering?
33. What geometric factors influence the distribution of undepleted solar radiation at the top of the atmosphere?
34. What are Bohr's postulates?
35. What is an energy budget?
36. What are aphelion and perihelion and when do they occur?
37. What is the declination angle?

38. Completely explain why Earth has seasons.
39. How does the distribution of undepleted solar radiation at the top of the atmosphere vary through the day or the year?
40. How much energy does the Earth receive from the Sun at a particular location on a particular day of the year?
41. In what ways could a slab of soil gain or lose energy?
42. What are the components of the surface energy balance? What is the sum of these components at the top of the atmosphere?
43. Where are there net gains and losses of energy at the Earth's surface?
44. Why do meteorological disturbances even exist?
45. What are Milankovitch cycles?
46. Why is the work of Johannes Kepler important to us?