Exam composition: 60% fill in the blank with multiple choices (30 questions); 40% Sketch, Explain, Brief Essay, or Solving Problems (total 5 questions, 8 points each). No derivations, no complicated calculations. Majority of the questions are explanatory and based on notes online. You’ll need paper, pencils, erasers, and a ruler. You’ll be given a WORD file online. For drawing, you’ll need to draw on a piece of paper & take a picture of your draw and send it to me separately or insert your picture files into your WORD file.

Multiple choice questions from Lecture 13 Notes:
1. Definition and shape of radar sample volume. (Page 3)
2. What is radar range folding? (page 3)
3. Relationship of radar received power and reflectivity factor and the distance between radar antenna and the target. (page 5, radar equation)

LECTURE 14 Notes: Doppler Effect
1. What is Doppler effect? Explain how the frequency shift is caused by the movement of the target: three conditions, part II question (Notes page 1).
2. What is maximum unambiguous velocity? What parameters determine it? (Vmax=+/− λ (PRF)/4) (Notes page 3).
3. What is Doppler dilemma? What is the relationship between maximum unambiguous velocity (Vmax) and maximum unambiguous range (Rmax) (Notes page 3-4)?

LECTURE 14 slides: Range and velocity folding; Interpreting Doppler velocity patterns
4. What is multi-trip echo? Be able to recognize it on radar maps (Slide # 3-9).
5. Given the maximum unambiguous velocity and the actual radial velocity value, you should be able to calculate the aliased/folded velocity (slide 10-12).
6. (Part II question) Given Doppler velocity images, you should be able to plot the corresponding vertical profiles of wind speed and direction (slide 16-29, and reading material online: the guide for interpreting Doppler velocity patterns).

LECTURE 16: Meteorological targets
7. Clouds: What is the cloud drop size distribution (slide 6-7)? Which wavelength radar can detect non-precipitating clouds? Give examples. (Slide 2 & 5)
8. The relationships between particle diameter and rain rate/liquid water content/radar reflectivity factor: rain rate ~ D³ or D⁴, liquid water content ~ D⁵, radar reflectivity factor ~ D⁶. (slide 8-9)
9. Why radar doesn’t detect snow very well? Why the radar power received back from snow and ice is 7 dB less than it would be if a radar were looking at liquid precipitation? (slide 10-13)
10. What is bright band? How does bright band form? (slide 14-16). Please list four effects (slide 16), be able to sketch the figure in Slide 17. (part II question)

LECTURE 17: Z-R relationship, Hail, Attenuation, Space weather radar
11. What measurements are used to determine the Z-R relationships (slide 4)?
12. How to determine hail using radar reflectivity (slide 5-6)?
13. What is a flare echo (slide 10-12)?
14. What is attenuation? What factors is the attenuation amount dependent on? (slide 13-20)

LECTURE 18: Satellite orbits
1. How to determine the orbit (altitude above Earth surface) of a circular geostationary satellite? (slide 5-7)
2. Definition of prograde orbits and retrograde orbits. (slide 15-16)
3. Definitions of Keplerian orbit (slide 19-20), sun-synchronous orbit (slide 22-23), geostationary orbit (slide 30), polar orbit (slide 23, 38), low earth orbit (slide 23, 38), and equatorial orbit (slide 38).
4. Explain and sketch the difference between Keplerian orbit and sun-synchronous orbit (slide 22). Part II question.
5. Compare the difference between sun-synchronous orbit and geostationary orbit (definitions, advantages and limitations) (slide 23-26, 30, 32, 35), and the difference between polar orbit and low earth orbit (slide 38-42).

Part II question.
6. How to keep an orbit sun-synchronized? (slide 24)

LECTURE 19: Operational Remote Sensing in Visible, IR, and Microwave Channels
7. Differences among conical scan, cross-track scan, and pushbroom scan. (slide 55, please review the NCAR COMET lecture online)
8. Interpreting visible, IR, and water vapor images (slide 5-11). What is in the brightest regions in visible, IR, and water vapor images, respectively (slide 11)?
9. Which radiation processes are important in 1.4, 10, 19, 22, 37, 50-60, and 85 GHz? (slide 32-40).
10. Why microwave-based rainfall retrieval is better than IR-based rain retrieval? (slide 32, 50-53).

LECTURE 20: Distinguishing different image types and Identifying weather systems
11. What is the difference between visible and IR images? (slide 8)
12. What are the four properties used in the Dvorak TC intensity estimation technique? (slide 44)

LECTURE 21: Identifying clouds
   No questions from this lecture