The following is a general outline of topics from the second half of the semester, which may be covered on the final exam.

I haven’t repeated all the topics listed in the midterm review sheet (which covered up through Chapter 5, and part of 8), but the final exam is comprehensive, so you should study those midterm topics as well. The final will tend to emphasize material from the second part of the course, for the most part “applications” of remote sensing. However you still need to know the basic principles and techniques from the first half, to understand those applications.

This is a list of the topics, not the material itself. For that material you’ll need to review the text by Sabins, your lecture notes, and the PowerPoint lecture handouts.

While you do need to know facts, the emphasis will be not be on memorizing facts but rather on applying general principles. For example don’t try to memorize the fact that urban areas are bright in radar images, – remember that “corner cubes” reflect the radar signal back to the source, and urban landscapes contain lots of “corner cubes”. Similarly, remember that multiple reflections depolarize radar signals. Then you can apply those principle to many situations.

Besides material from the lecture, material covered in the labs may also appear on the final exam. I haven’t listed that material explicitly in this outline. Review your lab reports.

We’ll spend much of Friday May 4 reviewing the material. Come with questions.

The exam will be open book (Sabins only) and open notes. You should bring a calculator. I’ll provide a list of equations and constants, but you will need to know how to use them.
Chapter 6 – Radar Technology and Terrain interactions

General construction of radar systems
What determines Range Resolution
What determines Azimuthal Resolution for
  a) Real apertures, b) Synthetic Apertures
Geometry of radar beam
  Depression angles, look direction, cardinal effects
Radar reflectivity of different surfaces
  Effects of roughness, dielectric properties, water content,
  right angle reflectors, specular reflection from smooth surfaces
  Backscatter coefficient
Distortions in Radar systems
  Shadows, Foreshortening, image layover
Polarization: HH, HV, VV, VH
Interferometry

Chapter 7 – Interpretation of radar images

Don’t try to know all the different radar systems mentioned in this chapter – just know how to apply the Chapter 6 principles to interpretation of a few basic types of surfaces we discussed, in particular vegetation (such as the Mahantango Mountain area of Pennsylvania shown in Fig. 7-15), and rough (aa) vs. smooth (pahoehoe) volcanic terrain in Hawaii, and the, and the Magellan observations of Venus and Cassini radar observations of Titan.

Chapter 8 – Digital image processing
Three “divisions” of image processing
Image restoration
  Photometric corrections: de-striping, correcting for atmospheric scattering, filtering to reduce random noise.
  Also, calibration of digital data (from lecture, not in book)
Geometric corrections: restoring line offsets, replacing bad lines or pixels, and correcting for camera or scan distortions
Image enhancement
  Contrast enhancement, density slicing, edge enhancement, various color transformations.
  Merging data in various ways, such as producing mosaics, merging color, and creating artificial stereo.
  Understand the basics of digital filters including smoothing and edge detection, using various “kernels”
Information extraction
  Image ratios to extract composition information
  Temperature measurement from IR data
  Change detection
  Principal-component analysis
Multispectral classification
  Supervised vs. Unsupervised
  Cluster analysis, such as K-Means
  More sophisticated mathematical indexes
  such as NDVI and others – covered later
  under specific applications

Map projections – in more detail than shown in book (see lecture)
  Basic principles of projecting spherical surface to flat plane.
  Why certain projections are best for certain applications, because they
  minimize the most objectionable distortions, or they
  minimize them over the area of interest.

Orthographic projection
Regular Cylindrical Projections
  Choice of different types of distortions:
    Plate Carrée (Equirectangular) vs. Mercator vs. Miller
Transverse Cylindrical Projections
  Small distortion along a given meridian
  Basis for UTM projections and coordinates, and USGS 7.5’ topos
Oblique Cylindrical Projections
  Space Oblique Projections (for Landsat)
  Misc. Other projections
Differences between raster (pixel) and vector data
Color transformations

(Note: Classification methods and spectral unmixing covered primarily in the labs is also
fair game to be on the exam, as are detailed indices such as band depth ratios.)

Chapter 9 – Meteorological, Oceanographic, and Environmental Applications
Ozone Mapping (TOMS)
  Nature and causes of Antarctic ozone hole, seasonal effects
  TOMS use of UV backscatter to measure ozone
  Units to measure atmosphere abundance:
    cm-atmospheres (and Dobson units)
    (I don’t expect you to remember how many cm-atm per Dobson
     units, but you should understand what a cm-atm is.)

Rainfall (Precipitation) mapping
  Importance of measurement
  Difficulties in measuring this remotely
  “Proxy” measurements related to rainfall
    Radar measurements of raindrops (not cloud particles)
    IR measurements of coldest (tropical) clouds
    Passive microwave observations
    Emission observations
    Use of polarization (scattering)
Snowcover
  Snow cover area estimates in visible
Distinguishing clouds from snow using spectral differences
Use of Snotel (ground truth) to calibrate remote observations
Gamma ray observations

Sea Ice and Glaciers (more detailed than book – from lectures)
Importance of radar
  Can see through clouds, characterize roughness, measure
  small movements through interferometry
Applications of Canada’s Radarsat 1&2 (from lecture)
  Advantages of multiple polarizations
  for characterizing sea and land ice
Laser Altimetry (IceSat) for measuring ice thickness
Differences between ice shelves and ice sheets
Recent changes in Antarctica – global climate change

Ocean Floor topography
  Indirect radar measurements of “large-scale” topography
  from ocean surface height
  Side-scan sonar and similarities to synthetic aperture radar

Gravity Measurements
  GRACE and GRAIL (dual) satellite techniques

Vegetation (Chapter 11 from Jensen – or from lecture)

Typical Leaf Spectra
  pigments
  changes with season
  reflection and transmission
  changes with water content
  differences between types of vegetation
Vegetation Indices
  SR and NDVI
  Tasseled Cap and use of scatter plots
Evergreen vs. deciduous spectra
Angular effects (BDRF’s)
Difficulties in distinguishing vegetation types with single observations
Phenology (seasonal cycles)
Landscape ecology metrics
Chapter 10  –  Oil exploration
5 stages as detailed on pg. 339:
1) Regional remote sensing reconnaissance
2) Reconnaissance geophysical surveys
3) Detailed remote sensing interpretation
4) Seismic surveys
5) Drilling

Two examples covered in more detail:
Sudan
  Recognition of sedimentary basins
  General landform/landcover mapping to aid on-the-ground logistics

Central Arabian Arch
  Regional geologic mapping of unexplored areas
  Recognition of subtle anticlines in this type of terrain

Chapter 11  –  Mineral exploration
Rather than covering all the examples in this chapter we concentrated on general principles plus the specific examples from Goldfield, NV and from the Hewson et al. 2005 paper

Lineaments and their relationship to mineralization
General principles related to ore bodies (from the lecture more than the text)
Specific patterns of minerals at Goldfield, NV, as related to the above.
Expected spectra of minerals which can be detected
  Use of certain minerals as proxies for others
  Alteration products – clays and iron minerals
  Difficulties in directly detecting quartz (or precious metals)
Detection of above minerals using Landsat TM data
  Classification based on band ratios
  Unsupervised classification results
  Resulting Geologic Maps
Use of hyperspectral data to identify specific minerals
  (band ratios, band depth ratios)
Unmixing techniques and mineral abundance images

Chapter 12  –  Land use and land cover

The Multilevel Classification System
  The three (or more) levels of classification
Reasons to use a multilevel system
Different types of data needed to classify at the three different levels
The general types of classification performed at the different levels
(Again – don’t try to memorize the numbers of the multiple classes, but understand how they are used and why.)
You are not responsible for the second part of the chapter, on GIS systems.

Chapter 13 – Natural hazards

This chapter mostly serves as a summary and application of techniques discussed in earlier chapters.

Recognition of faults, earthquake hazards, landside hazards
Volcanic plumes

Chapter 14 – Comparing Image Types: Summary

Again, this chapter serves as a summary of the multiple techniques discussed earlier, all applied to one particular region (Death Valley). Don’t memorize details about the Death Valley results, but be prepared to know the advantages of applying multiple techniques to a given region.
Other topics, not from text

Review the more detailed discussion of mineral spectra and the mineral mixture -- abundance estimating techniques, discussed above under the Chapter 11 Goldfield results.

Also review the more quantitative analysis performed in the various labs. I don’t expect you to remember the details of the individual sites, but do want you to know how to apply the various techniques discussed.

Lunar geology and remote analysis of lunar minerals

- Very general geological history of the moon
- Magma ocean and anorthosite crust
- Declining impact cratering
- Later eruption of mare basalts

“Simplicity” of lunar remote sensing
- Relatively simple geologic history
- Simple or absent “weathering” processes
- Mechanically “simple” regolith generation
- Lack of vegetation

Albedo differences between highlands and mare

Recognition of general mineral types based on spectra
- Use of wavelength shifts in bands to determine composition
  - Again – don’t memorize names of minerals, but understand how the techniques work. For example, if presented with reference spectra, and one of “unknown” composition, you should be able to determine its type and composition.

Fe and Ti abundance techniques
- Again – don’t memorize formulae – but if presented with graphs or data and formulae, you should know how to use them.