

- Study Tips:**
- Compare your notes to text in the book
  - Much of the covered material is only in the class notes
  - Work over review questions in the book and on the web
  - Work over previous exams on the web
  - Work over theory parts in the lab manual (1-7)

*Note: This Final Exam consists entirely of multiple choice questions (ALL answers on NCS sheets). There will be true/false and quantitative (calculation/problem) components.*

*Bring to the exam: pen/pencil calculator notepad*

### List of Topics and Keywords Covered: (with references, compare syllabus)

- 0. Introduction - General** (class notes only)
- Weather vs. Climate
- 1. Atmosphere** (A&B: p 1-22, 105-112, 425-432)
- air is a *fluid* (liquids and gases are fluids)
  - Composition of the atmosphere: 3 most abundant permanent gases, 3 most abundant variable cases
  - *Phase changes* of water: transitions between solid (ice), liquid (water) and gas (vapor) involve transfer of energy → *latent heat*
  - Greenhouse effect, and *greenhouse gases*, pollutants
  - Ozone, *ozone layer*, ozone hole
  - *Pressure*, definition, vertical structure
  - *Gas laws* (be able to use them, if formula given)
  - *Temperature structure* of the atmosphere, main layers of the atmosphere
- 2. Earth-Sun Geometry** (A&B: 48-60, CD 1)
- Principal motions of Earth: orbital rotation, revolution
  - Orbital characteristics: ecliptic inclination, eccentricity, perihelion change
  - Sun's altitude, noon sun angle and latitude, circle of illumination and day length, seasons
  - How does the solar altitude determine the amount of energy received on Earth?
- 3. Energy Transfer** (A&B: 39-42, CD 2)
- Energy, definition, conservation principle
  - System approach: Input - Output = Storage Change
  - Energy transfer modes (characteristics of each)
  - In which part of the Earth/Atmosphere system is each mode most important?
- 4. Radiation** (A&B: 42-84, CD 2)
- Spectrum, wavelengths, spectral ranges (UV, visible, IR, shortwave, longwave, solar, terrestrial)
  - Black bodies, gray bodies, emissivity
  - Radiation laws: Stefan-Boltzmann law, Wien's law, Kirchhoff's law (be able to use them if given)
  - absorption, reflection, transmission
  - Scatter and absorption, atmospheric windows, blue sky – white clouds
  - Main absorber gases for longwave radiation, and for shortwave radiation
  - Solar constant
  - Radiation balance, basic equation, balance at surface

- Where does longwave radiation come from? What causes it?
- Where does shortwave radiation come from? How is it affected?
- What is net radiation?
- Role of cloud cover in radiation balance, green house effect: back- or re-radiation
- Global distribution of radiation balance (latitudes, seasons)
- How do the surplus and deficit regions of net radiation get compensated?

**5. Energy and Water Balance** (A&B: p.72-84, CD 2)

- Role of transport by atmosphere and oceans in energy balance
- Surface energy balance equation (all 3 energy transfer modes), *concept equation: need to know it - accounts for inputs, outputs and storage change*
- Conduction - ground heat flux
- Convection - sensible heat flux
- Convection latent heat flux - evaporation flux
- latent heat and sensible heat, phase changes of water
- Water balance → link to energy balance

**6. Temperature** (A&B: p.78-98)

- relationship energy – heat – temperature
- temperature gradients and heat flow
- controls on air temperature (solar radiation, clouds, wind, land/ocean)

**7. Atmospheric moisture** (A&B: p.132-162, CD 3, 4)

- Forms of water in the atmosphere (vapor, droplets, ice)
- Partial pressure of vapor = vapor pressure
- concept of saturation and equilibrium
- The Clausius-Clapeyron curve: need to be able to work with it
- measures of humidity (vapor pressure, relative humidity, specific humidity, dew point temperature)
- Conservative measures of humidity
- variations of humidity (daily, global, annual, with temperature)

**8. Atmospheric Stability** (A&B: p.168-182, CD 4, LM 8)

- Lapse vs. inversion conditions
- adiabatic cooling/warming, DALR, SALR, ELR
- lifting condensation level
- static stability: stable stratification, unstable conditions (recognize in temperature profile, consequences)
- absolute stability/ instability, conditional instability
- how far can an air parcel of a given temperature rise in the atmosphere (given a temperature profile)?
- factors influencing stability and lifting of air: solar heating, advection, orographic lifting, convergence, frontal wedging

**9. Clouds and Precipitation** (A&B: p.182-214)

- condensation, evaporation and saturation
- ways to reach saturation (cooling, moisturizing)
- cloud formation, cloud condensation nuclei (CCN)
- cloud types: altitude (low, middle, high), appearance (stratus, cumulus, cirrus)
- formation of precipitation; Bergeron process, collision-coalescence process
- types of precipitation, with regard to cloud types, temperature profile

**10. Forces and Winds** (A&B: p.104-127, CD 5, 6, 7)

- pressure, horizontal pressure gradients
- forces, velocity (vector: speed and direction) , acceleration, force balance, net force
- types of forces affecting horizontal air motion
- pressure gradient force
- Coriolis force – Coriolis effect
- geostrophic wind, characteristics (northern hemisphere vs. southern hemisphere), Buys-Ballot's law (*conceptual law: need to know it*)
- gradient wind: cyclonic flow, anticyclonic flow, convergence, divergence
- effect of friction force, surface winds

#### **11. Wind Systems** (A&B: p.227-254)

- concept of scales of winds (micro, meso, macro/synoptic)
- Differential heating and generation of thermal circulations: Sea/Land Breeze; Mountain/Valley Breeze; Monsoons
- Katabatic winds: drainage of cold air
- Mountain winds: Foehn/Chinook/Santa Ana
- Global circulation: the one-cell and three-cell models (Hadley cell; Ferrel cell; Polar cell; Innertropical Convergence Zone, ITCZ)
- Polar front and jet stream

#### **12. Weather Systems** (A&B: p.265-309, CD 8)

- definition of air mass and characteristics
- definition of source regions and typical source regions in and around North America
- types of air masses
- air mass modification
- relation between fronts and air masses
- definition of a front
- warm fronts and associated geometry, flow, stability, cloud, and precipitation patterns
- cold fronts and associated geometry, flow, stability, cloud, and precipitation patterns
- occluded fronts
- structure of mid-latitude cyclone (dimension, pressure distribution, wind flow, position of fronts)
- generation and life cycle of a mid-latitude cyclone, associated weather patterns