

Conceptual Summary/Outline of Topics Covered Before 1st exam

- a) Probabilities:
 - a. One random event is independent of the next
 - b. Probabilities of exclusive events multiply (“and”)
 - c. Probabilities of inclusive events add (“exclusive or”)
 - d. All probs sum to 1 (normalization)
 - e. Probs must be non-neg
 - f. You can observe 1 thing many times or many things once
 - g. Particular outcomes are likely because their multiplicity is high
- b) Measurements have uncertainties
 - a. Uncertainty is characterized by σ (68% of trials within 1σ)
 - b. Reduce uncertainties by taking multiple readings
- c) Exponential growth and decay
 - a. Applies when what-you-will-have depends on what-you-have-now
 - b. Frequency of compounding varies
 - c. Continuous compounding (only) leads to $N=N_0e^{\lambda t}$
 - d. Applies to decay (radioactive) if $\lambda < 0$
- d) Philander Chap 1
 - a. Changes in the environment can be exponential in nature and we don’t know at what stage in the growth curve we presently exist.
 - b. Scientific results have uncertainties. Don’t use this as an excuse for failing to make policy decisions (e.g. Failure to act on NE fisheries).
 - c. Policy should mirror scientific method: periodically review and adjust as observations indicate success/failure
- e) Philander A1.2 and Ruddiman and Broecker
 - a. Past climates help us understand present and future, since we can’t conduct a controlled experiment.
 - b. Past climates recorded in archives:
 - i. Sediment cores (lake and ocean)
 - ii. Ice cores
 - iii. Glacial moraines
 - iv. Corals
 - v. Tree rings
 - vi. Loess (windborne dust)
 - vii. Historical records (accidental)
 - viii. Deliberate historical and instrumental
 - c. Methods of dating
 - i. Radiometric
 - 1. atomic structure and isotopes
 - 2. radioactivity: β -decay, e^- capture, fission
 - 3. ^{14}C : origin and fate and limitations
 - 4. Rb/Sr: challenges and advantages
 - ii. Layer counting
 - iii. Cross correlation (including magnetic field reversals)
 - d. Limits on resolution of dates in archives
- f) Philander Chapter 2
 - a. Planet (actually, its climate) is both fragile (our perspective) and robust (life in general)
 - b. Emphasis on role of observation as guide for scientific inquiry and refinement of theory (e.g. caloric theory of heat)
 - c. Conservation laws (momentum, charge, energy/mass, angular momentum)
 - d. Chaos: Strong dependence on initial conditions

- i. Limits on weather predictability due to limited knowledge of initial conditions
 - ii. “Chaotic” is not the same as “random” or “without order”
 - iii. Different scales of predictability: seasonal (yes) vs. weekly (no)
 - e. Models: Eliminate all irrelevant properties. Strip system to essence to make predictions possible. The “essence” depends on the question you are trying to answer. A model that is good for one purpose might not be good for another.
 - g) Philander A2.1
 - a. Gaia Hypothesis and Daisyworld: focus on feedbacks
 - i. Feedback: use of info about present state of system determines actions used to regulate system.
 - ii. Positive vs. negative feedbacks
 - h) Philander Chapter 3 and A3.2-3.5
 - a. Temperature regulation of planets:
 - i. Distance from sun
 - ii. Albedo
 - iii. Atmospheric thickness and composition
 - b. Heat transfer: Heat is random (disordered) motion of molecules
 - i. Radiation: Continuum of E-M wavelengths and energies
 - 1. Amount and wavelength is proportional to T^4
 - 2. Wien’s law (T from λ_{max})
 - 3. Blackbody curves: Information from area and peak, units.
 - 4. Kirchhoff: good absorbers are good emitters
 - ii. Conduction: collisions of molecules with adjacent molecules (good and poor conductors)
 - iii. Convection (really a subclass of conduction).
 - 1. Fluid (air, water, magma) in contact with hot surface
 - 2. Heat transfer to interface layer of fluid by conduction, followed by bulk motion carrying heated fluid away.
 - 3. In absence of active device for circulation of fluid, gravity is essential (buoyancy driven convection)
 - 4. Can be very effective (i.e. leads to rapid heat transfer).
 - iv. How does insulation work (fiberglass batting, space blankets, etc.): suppression of convection, poor conductor.
 - c. Scattering of Light
 - i. Young’s double-slit experiment proves wave nature of light
 - ii. Depends on both size of scatterer and λ .
 - iii. If λ is large compared to R, scattering $\propto \lambda^{-4}$
 - iv. Leads to blue skies and sunsets
 - d. Absorption and emission of light
 - i. Einstein Photoelectric effect proves particle nature of light: essential for discrete absorption lines.
 - ii. Bulk (blackbody) vs. Molecular/Atomic (spectral lines)
 - e. Greenhouse effect
 - i. Radiative balance: energy in = energy out
 - ii. Transparent atm in visible, opaque in IR
 - iii. Models of increasing sophistication
 - 1. blackbody, no albedo, no atm.
 - 2. albedo, no atm
 - 3. no albedo, single-layer atm
 - 4. albedo, single-layer atm
 - 5. no albedo, multi-layer atm
 - 6. etc...
 - i) Philander Chapter 4 and A4.1-4.2
 - a. Atmosphere is no longer static or dry
 - b. Concepts of pressure: with and without gravity.
 - c. Ideal gas law (conceptual derivation)

- d. Temperature: a willingness to give up energy
- e. Heat Capacity and Specific Heat Capacity
- f. Conceptual description of hydrostatic balance
- g. Combination of hydrostatic balance and pressure leads to barometric equation (in case of isothermal atmosphere)