Introduction

• Syllabus
  - Online

• Grading
  - There will be 4 total examinations
  - Exam #4 is cumulative (covers whole summer).
  - Each examination will count 22.5% of your grade (90% total).
  - There will be NO make-up examinations.
  - Participation with iClickers will count 10% of your grade.
  - The ONLY extra credit is with the iClickers (extra credit is not a substitute for studying and learning the material). Up to 3 for correct answers.
Introduction

- **Textbook**
  - Universe by Freedman, Geller and Kaufmann
    - Or split edition, Universe: Stars and Galaxies by Freedman, Geller and Kaufmann

- **Auxiliary Materials**
  - Personal Response System
    - iClicker
Introduction (continued)

• Web syllabus and notes
  - Will be updated routinely; check back often

• Observing Sessions not available in the summer
  - Offered on campus in spring and fall for your learning experience and enjoyment
  - Summer - some special events

• FGK Chapters 4 & 5 Review
  - Basic ideas reviewed in this lecture
    • Read textbook and think about what is being said
Kepler’s Laws of Planetary Motion

• Kepler’s First Law of Planetary Motion
  – planets orbit sun in an ellipse with sun at one focus

• Kepler’s Second Law of Planetary Motion
  – planets sweep out equal areas in equal times

• Kepler’s Third Law of Planetary Motion
  – orbital period squared is proportional to semi-major axis cubed
    – $P^2 = a^3$

  » Requires proper units (AU and years)
Newton’s Laws of Motion and Gravity

• Newton’s First Law of Motion
  - body at rest tends to stay at rest and body in uniform motion will stay in straight line uniform motion unless acted upon by an outside force

• Newton’s Second Law of Motion
  - the acceleration of a body is proportional to the force being applied
  \[-F = m a\]
Newton’s Laws of Motion and Gravity

• Newton’s Third Law of Motion
  - for every force there is an equal and opposite force (action and reaction)

• Newton’s Law of Gravitational Attraction
  - force is proportional to masses and inversely proportional to the distance squared

\[ F = \left( \frac{G m M}{r^2} \right) \]
The Electromagnetic Spectrum from Longest to Shortest Wavelengths

- Radio Waves
- Microwaves
- Infrared Radiation
- Visible Light
  - Red, Orange, Yellow, Green, Blue, Indigo, Violet (ROYGBIV)
- Ultraviolet Radiation
  - UV-A, UV-B
- X-rays
- Gamma Rays
Wien's Law

- Peak wavelength is inversely proportional to the temperature of the blackbody.
Stefan-Boltzmann Law

- Energy radiated by blackbody is proportional to the temperature to the 4th power

\[-E = \sigma T^4\]
Kirchoff’s Spectral Laws

• Kirchoff’s Spectral Laws (empirical)
  - Continuous Spectrum
    • what produces them?
  - Emission Spectrum
    • what produces them?
  - Absorption Spectrum
    • what produces them?
Kirchoff’s First Spectral Law

- Any hot body produces a continuous spectrum
  - if it’s hot enough it looks something like
  - digitally like this

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Intensity

Wavelength
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![Graph showing a continuous spectrum with intensity and wavelength axes](image-url)
Kirchoff’s Second Spectral Law

- A gas to which energy is applied, as heat or a high voltage, will produce an emission line spectrum like this

- or digitally like this
Kirchoff’s Third Spectral Law

• A gas placed between a continuous spectrum source and observer will produce an absorption line spectrum like this

- or digitally like this
The Photoelectric Effect

• A prelude to the Bohr atom
  - experiment explained by Einstein, but performed by others
    • what caused this strange result?
The Photoelectric Effect

• A prelude to the Bohr atom
  - experiment explained by Einstein, but performed by others
    • what caused this strange result?
Prelude to Bohr

• Einstein used Planck’s quantized particles
  - energy of photon is related to frequency of light, not intensity
  • need high enough frequency to get electrons released from metallic surface
    - $E = h f$
Bohr’s Atom

• Best described the workings of the Hydrogen atom
  - one proton and one electron “around” the proton moving in orbits that are discretized (quantized) so that no intermediate orbits are allowed

Absorption

Emission
Maxwell’s Electromagnetism

- Electricity according to Gauss
  - relates electricity to electric charge
- Faraday’s Law
  - relates electric fields to magnetic fields
- Magnetism according to Gauss
  - relates magnetism to electricity
- Ampere-Maxwell Law
  - relates magnetic field to electricity

\[
\nabla \cdot E = \frac{1}{\varepsilon_0} \rho
\]

\[
\nabla \times E = -\frac{\partial B}{\partial t}
\]

\[
\nabla \cdot B = 0
\]

\[
\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t}
\]

Don’t worry about notation here.
Doppler Effect

- A change in measured frequency caused by the motion of the observer or the source
  - classical example of pitch of train coming towards you and moving away
Conclusion

• To understand the stars (and our Sun is a star), galaxies, and the universe at large (cosmology) you need to understand
  - Physics
    • Forces (gravity, electromagnetic, strong, weak)
    • Matter (protons, electrons, quarks, bosons, etc.)
    • Theories, Laws and Effects
      - Newton’s, Kepler’s, Kirchoff’s, Stefan-Boltzmann, Doppler, Photoelectric, Relativity, etc.
  - Chemistry
    • Atoms, elements, molecules and their models (e.g. Bohr)
  - And even a little biology for SETI