Physics H7C, Spring 2015

Honors modern physics, electromagnetic waves and optics

Instructor:

- Prof. Daniel Kasen (kasen@berkeley.edu)
- Prof. Office hours: Monday 10-11 AM in 355 Campbell Hall
- Thursday 11-12 AM in 355 Campbell Hall
- GSI: Zach Stone (stone@berkeley.edu)
- GSI Office hours: Monday 11-12 AM and Wednesday 10-11 AM in 443 Birge

Course Materials and Schedule:

- Course and Lab Schedule
- Topics and Recommended Reading
- Lecture Notes and Figures
- Previous Exams

Suggested Course References:

- Tipler and Llewellyn, *Modern Physics, sixth edition*
- Hecht, *Optics*
- the *Feynman Lectures* are available online (Links to an external site.)

Exams

- Midterm #1: Friday, Feb 27, in class (9:10 - 10 AM)
- Midterm #2: Friday, Apr 17, in class (9:10 - 10 AM)
- Final Exam: Monday, May 11, 7-10 PM

Homeworks

- Problem sets (and eventually their solutions) are available HERE. Homeworks are due most Fridays by 5 PM in 251 LeConte.
- Late homeworks turned in after the deadline will generally not be accepted. However, you are allowed a one-week grace period on one problem set to account for unavoidable circumstances. If other circumstances arise, please come see me.
- You may learn from and work alongside with classmates on the homeworks, but the solutions you turn in must be your own, and not copied from a friend or outside source.

Grading

- problem sets (25%)

- midterm exam #1 (20%)
- midterm exam #2 (20%)
- final exam (35%)
- lab: all must be completed; your grade will drop by one level (e.g., A to A-) for each lab missed.

Topics and Reading for H7C, Spring 2015

Each numbered topic will occupy approximately 1 or 2 classes

(T&L = Tipler and Llewllyen, H = Hecht)

Electromagnetic Radiation and Optics

1. Review of Maxwell's equations (H 3.1, 3.2)

- differential form of maxwell's equations
- conceptual picture of electromagnetic waves

2. Electromagnetic Waves (H 2.1-2.7, H 7.1)

- plane wave solutions
- frequency, wavelength, and intensity
- complex representation
- Phase differences and interference

3. The Electromagnetic Spectrum (H 7.1)

- Adding sinusoids -- Fourier transforms and spectra
- the electromagnetic spectrum, wavelengths and frequencies

4. Radiation from Accelerated Charges (H 3.4)

- electric dipole emission
- pictorial “derivation” of Larmor’s power formula

5. Interaction of Radiation with Matter -- Scattering

- simple classical model of an atom -- harmonic oscillator
- solving the driven oscillator
- Rayleigh scattering, and the origin of the blue sky

5. Interaction of Radiation with Matter -- Index of Refraction

- the speed of light in medium and the index of refraction
- dispersion of radiation in medium

7. Laws of Refraction and Reflection (H 4.3-4.5)

- Fermat's principle (principle of least action)
- Laws of reflection and refraction (Snell's law)

8. Examples of Refraction and Reflection (H 4.7)

- total internal reflection
- rainbows, fiber optics, SOFAR

---------- midterm 1 ----------

9. Mirrors (H 5.4)

- real and virtual images
- focal points
- plane mirrors, spherical mirrors, the mirror equation

10. Lenses (H 5.2, 5.7)

- thin lenses, lens equation, lens-makers equation
- transverse and angular magnification
- multiple lenses, human eye

11. Polarization (H 8.1-8.6)

- linear and circular polarization
- polarization by scattering
- anisotropic materials: dichroism and birefrengence

12. Interference (H 9.1-9.4)

- two-slit (Young's) experiment
- thin film interference

13. Diffraction (H 10.1-10.3)

- Franhofer (far-field) diffraction
- double slit with diffraction

Special Relativity

1. Roots of Relativity (T&L 1.1, 1.2)

- Maxwell's Equations and moving frames
- Michelson-Morley experiment
- Einstein’s postulates
- the relativity of simultaneity
- light clocks and time dilation

2. Lorentz Transformations (T&L 1.3)

- coordinate and Galiliean transformations
- derivation of Lorentz transformations

3. Consequences of Lorentz Transformations (T&L 1.4)

- time dilation
- length contraction
- relativistic velocity addition

4. Space-Time Diagrams (T&L 1.3)

- geometrical representation of Lorentz transformations
- space-time interval and Lorentz invariants

5. Paradoxes (T&L 1.6)

- the twin paradox
- the barn and pole paradox

6. Relativistic Kinematics and Four Vectors (T&L 2.1, 2.2)

- relativistic momentum
- relativistic energy
- four vectors
- lorentz invariants
- invariant mass and E = mc2

7. The hyperbolic geometry of spacetime (not in book)

- hyperbolic angles and functions (cosh and sinh)
- Lorentz transformations as hyperbolic rotations

8. General Relativity (T&L 2.5) (bonus)

- the equivalence principle
- gravitational time dilation and redshift
- curved spacetime and black holes

---------- midterm 2 ----------

Quantum Mechanics

1. The Photoelectric Effect (T&L 3.3)

- quanta of electromagnetic radiation (photons)
- Einstein's idea: E = h*nu

2. Atomic Spectra and Bohr's atom (T&L 4.1-4.3)

- spectral lines
- quantized energy, angular momentum

3. Matter Waves (T&L 5.1-5.6)

- Debroglie wavelength
- the uncertainty principle and wave-particle duality

4. The Schrodinger equation (T&L 6.1-6.4)

- the wavefunction and probability distributions
- Separation of variables and the time-independent Schrodinger equation

5. Solutions of the Schrodinger equation (T&L 6.1-6.4)

- free particle
- particle in a box (infinite square well)
- potential step

6. Eigenvalues and Eigenfunctions

- quantum operators
- non-commuting (incompatible) operators

7. Quantum tunneling (T&L 6.6)

- wavefunction in unallowed regions
- reflection and transmission

8. Quantum Treatment of the Hydrogen Atom (T&L 7.1-7.3)

- 3D Schrodinger equation and separation of variables
- quantum numbers and energy states

9. Multi-particle system

- particle indistinguishability
- Two-particle wavefunctions
- Pauli-exclusion principle

---------- final----------

10. Interpretations of Quantum Mechanics (Bonus)

- Schrodinger's cat
- hidden variables interpretation
- the Copenhagen interpretation
- Consciousness Causes Collapse
- the many-worlds interpretation