PHYS2063 Wave Physics Fall 2022 November 15, 2022

This is a schedule of material that we will cover this semester. References are to the textbook *The Physics of Vibrations and Waves, 6e* (Wiley 2005) by H. J. Pain, and also to the textbook-in-preparation *Introduction to Mathematical Concepts in Physics*.

Week 1

Tue 23 Aug: Course introduction and the "hidden agenda." Forces on a mass hanging from a spring. Differential equation $F = ma$. Solving for the motion with initial conditions. Simple Harmonic Motion amplitude and phase.

Thu 25 Aug: Horizontal Simple Harmonic Motion. Taylor Series and Euler's Formula. Solution using the $e^{i\omega t}$ ansatz. Conservation of mechanical energy.

Reading in Pain: Chapter 1

Reading in Concepts: Sections 2.2, 2.4, 3.4.1

Week 2

Tue 30 Aug: Differentials. The product rule and the chain rule. Conservation of energy in the Simple Harmonic Oscillator. Integration by parts. The Gamma function. Gaussian integrals. Stirling's approximation.

Thu 1 Sep: Damped Harmonic Motion. The differential equation $F = ma$ and time scales. Solution using the $e^{i\omega t}$ ansatz. Emphasize underdamped case. Discussion of energy non-conservation. Analysis of the series LCR electrical oscillator.

Reading in Pain: Chapters 2, 3

Reading in Concepts: Section 3.4

Week 3

Tue 6 Sep: The motion of two equal masses connected by three equal springs. Analyze fully including normal modes. Try to have a demonstration handy.

Thu 8 Sep: Multiple equal masses and equal springs. Oscillations of triatomic molecules. *This class will use* Mathematica.

Reading in Pain: Chapter 4

Reading in Concepts: Section 3.7.1

Week 4

Tue 13 Sep: Coupled oscillations of a loaded string. Towards the Wave Equation.

Thu 15 Sep: The equation of transverse motion for a stretched string. The mathematics of partial differentiation. The shape of the normal modes for a string with fixed ends. Concepts of wavelength and frequency for sinusoidal waves.

Reading in Pain: Chapters 4, 5

Reading in Concepts: Sections 1.3.4, 5.1

Week 5

Tue 20 Sep: General solutions of the Wave Equation. Specific solutions of the Wave Equation, including pulse propagation and reflections at fixed and free ends.

Thu 22 Sep: General vibrations of a string with two fixed ends. The Fourier Sine solution for standing waves on a string.

Reading in Pain: Chapters 4, 5, 10

Reading in Concepts: Sections 4.5.1, 5.1, 5.2

Week 6

Tue 27 Sep: Examples of the Fourier sine solution for standing waves. *This class will use* Mathematica*.*

Thu 29 Sep: **Midterm Exam #1: Material through 27 Sep**

Reading in Pain: Chapter 10

Reading in Concepts: Section 5.2

Week 7

Tue 4 Oct: Review of vectors in 3D space, including dot product and cross product. Introduction to vector calculus. The gradient operator and scalar fields. *This class will use* Mathematica*.*

Thu 6 Oct: Vector fields. Divergence and curl. Gauss' Theorem and Stokes' Theorem.

Reading in Pain: ——

Reading in Concepts: Chapter 4

Week 8

Tue 11 Oct: Review of Maxwell's Equations in integral form. Derivation of Maxwell's Equations in differential form. Proof of the Continuity Equation and its implications

Thu 13 Oct: Maxwell's Equations in a vacuum. Electromagnetic potentials, and the vector potential as a solution to the wave equation. Introduction to electromagnetic waves.

Reading in Pain: Chapter 8

Reading in Concepts: Sections 4.3.3, 4.3..4

Week 9

Tue 18 Oct: Electromagnetic wave propagation. Plane waves in three dimensions and spherical waves in three dimensions. The Poynting vector as a carrier of momentum and energy.

Thu 20 Oct: Reflection and refraction at surfaces of non conducting materials. Introduction to geometrical optics.

Reading in Pain: Chapters 8, 9, 11

Reading in Concepts: —

Week 10

Tue 25 Oct: The evidence for "photons" from the photoelectric effect and the Compton effect. The importance of Planck's constant and the scale of quantum mechanical phenomena.

Thu 27 Oct: **Midterm Exam #2: Through 20 Oct, but primarily since Exam #1**

Reading in Pain: Chapter 13

Reading in Concepts: —

Week 11

Tue 1 Nov: Matter waves and the deBroglie hypothesis. Experimental evidence of wave phenomena for particles. Schrödinger's wave equation and conservation of probability.

Thu 3 Nov: **No class today**

Reading in Pain: Chapter 13

Reading in Concepts: —

Week 12

Tue 8 Nov: Quantum mechanical waves in one dimension. Reflection and transmission at a rectangular step.

Thu 10 Nov: Reflection and transmission in one dimension from barriers and wells.

Reading in Pain: Chapter 13

Reading in Concepts: ——

Week 13

Tue 15 Nov: Bound states in a box with infinitely high walls. Probabilities and expectation values.

Thu 17 Nov: Time dependence of expectation values; Bound states in a box with finite walls. Numerical solutions. The δ-function potential well.

Reading in Pain: Chapter 13

Reading in Concepts: ——

21-25 Nov Thanksgiving Break (No Classes)

Week 14

Tue 29 Nov: Introduction to nonlinear oscillations. The pendulum, including damping and driving. *This class will use* Mathematica.

Thu 1 Dec: **Midterm Exam #3: Through 17 Nov, but primarily since Exam #2**

Reading in Pain: Chapter 14

Reading in Concepts: ——