Physics Circle Topics Spring 2021

Weeks	Topics	Reference/Material	Mentor
Jan 9	Exam		
Jan 16	Coulomb's Law, Gauss's Law, Potential	HRW Ch. 21 - 24, PM Ch. 1 - 2	Sabina
Jan 23	Capacitors, Current, Resistance, Resistors	HRW Ch. 25 - 26 (a bit of 27), PM Ch. 3 - 4	Sabina
Jan 30	Magnetism, Biot-Savart, Ampere's Law	HRW Ch. 28 - 29, PM Ch. 5 - 6	Cagan
Feb 6	Faraday's Law, Inductors, Inductance, RC/RL Circuits, RLC Circuits	HRW Ch. 30, 27, PM Ch. 7 - 8	Gopal
Feb 13	Continue RLC Circuits, Driven RLC Circuits, Maxwell's Equations	HRW Ch. 27, 31 - 32, PM Ch. 8 - 9	Cagan
Feb 20	Laws of Thermodynamics, Ideal Gases, Heat Engines, Entropy	HRW Ch. 18 - 20	Cagan
Feb 27	Relativistic Kinematics (including Four-Vectors)	HRW Ch. 37	Gopal
March 6	Relativistic Dynamics, Collisions, Problem-Solving Strategies	HRW Ch. 37	Sabina

HRW = Halliday, Resnick, and Walker, *Fundamentals of Physics*, 10th edition. See here.
PM = Purcell and Morin, *Electricity and Magnetism*, 3rd edition. More advanced; only selections will be covered.

Week-by-week Outline

Week 1: (Coulomb's Law, Gauss's Law, Potential)

- Coulomb's Law, Definition of Electric Force and Field
- Configurations of Point Charges (short)
- Gauss's Law (Integral Form) and Evaluating Surface Integrals using Symmetry

- Examples: Point Charge/Spherical Shell (Shell Theorem), Line/Cylindrical Shell, Plane of Charge
- Matching Conditions for Electric Fields (e.g. difference in electric fields across a sheet of charge)
- Conductors, Insulators, and Dielectrics
- Electric Potential Energy and Electric Potential
- Electric Potential for Cases Described Above
- Definition of Capacitance and Capacitors
- Examples: Parallel-Plate Capacitors, Cylindrical Capacitors (?)
- Kirchkoff's Laws for Circuits
- Capacitors in Series and Parallel
- Energy of Capacitor

Week 2: (Capacitors, Current, Resistance, Resistors)
- Definition of Current
- Resistivity and Resistance
- Ohm's Law
- Resistors in Series and Parallel
- Energy of Resistor, Power of Resistor

Week 3: (Magnetism, Biot-Savart's Law, Ampere's Law)
- Definition of Magnetic Field and Magnetic Force
- Biot-Savart's Law
- Right-Hand Rule
- Ampere's Law (Integral Form) and Evaluating Line Integrals using Symmetry
- Examples: Current through a Wire, Current in a Ring, Solenoid
- Matching Conditions for Magnetic Fields

Week 4: (Faraday's Law, Inductors, Inductance, RC/RL Circuits, RLC Circuits)
- Faraday's Law and Lenz's Law
- Definition of Emf, Inductors and Inductance
- Examples: Solenoid
- Inductors in Series and Parallel
- Energy of Inductor
- RL Circuits: Solving the Differential Equation and Time Constants
- RC Circuits: Ditto
- RLC Circuits: Analogy to Simple Harmonic Oscillation, Solving the Differential Equation, Frequency of Oscillation, Underdamped vs. Overdamped vs. Critically Damped

Week 5: (RLC Circuits, Driven RLC Circuits, Maxwell's Equations)
- Finish RLC Circuits
- Driven RLC Circuits: Transient vs. Steady-State Solutions, Solving the Differential Equation, Frequency of Oscillation, Resonance, Phasors (?)

- Differential Forms of Gauss's Law, Ampere's Law, Faraday's Law (optional)
- Displacement Current and Maxwell's Equations (optional)
- Light is a Wave! (optional)

Week 6: (Laws of Thermodynamics, Ideal Gases, Heat Engines, Entropy)
- Zeroth and First Law of Thermodynamics
- Definition of Heat and Temperature
- Ideal Gas Law
- Energy of Ideal Gases (Constant-Pressure and Constant-Volume Specific Heat)
- Heat Engine Processes: Isobaric, Isochoric, Isothermal, Adiabatic
- P-V Diagrams
- Signs of Heat and Work
- Definition of Entropy and Second Law of Thermodynamics
- Carnot Engines and Efficiency

Week 7: (Relativistic Kinematics including Four-Vectors)
- Postulates of Special Relativity
- Simultaneity, Time Dilation, and Length Contraction
- Lorentz Transformations
- Four-Vector Notation
- Spacetime Diagrams
- Velocity Addition Formula (and Velocity Four-Vector?)
- Analyze Common Paradoxes: Twin Paradox

Week 8: (Relativistic Dynamics and Collisions)
- Relativistic Energy and Momentum
- Energy-Momentum Four-Vector
- Conservation of Energy-Momentum
- Relativistic Collision Problems