AP Physics B

Course Description

AP Physics provides a systematic introduction to the main principles of physics at the freshman college level, and follows the Physics B format. Physics B provides a systematic introduction to the main principles of Physics and emphasizes the development of problem-solving ability. Strong emphasis is placed on solving a variety of challenging problems. The subject matter is principally Classical Mechanics, Waves, and Electricity and Magnetism, with equal emphasis on these three areas. Additionally, some focus will be on Modern Physics concepts (post 1900). The laboratory components of the course offer many experiences dealing with advanced topics and skills while using both simple and sophisticated equipment.

Additionally, other learning opportunities exist for students beyond the classroom. All students participate in our annual Fairfield High School Physics Olympics competition in which students compete in small groups and as a class. We have modeled this event after the AAPT Physics Olympics, but have included experiments of our own design. These activities have been created to provide a fun and safe learning event for students, and will also help them review for final exams. Centered on key physics concepts, the activities will engage students in hands-on, minds-on experiments and provide a culminating experience for the students that they won't soon forget. We also take a group of students to compete at Yale University's annual Physics Olympics. Also, guest lecturers from various institutions have been invited in to speak with students, and field trips to museums have been arranged.

Instructional Materials:

Primary Text: Giancoli; *Physics for Scientists and Engineers with Modern Physics*, Prentice Hall, 4th Edition, 2007

Secondary Text: Cutnell & Johnson, *Physics*, Wiley, 6th Edition, 2004

Technology: Computers equipped with Vernier probes and data acquisition and analysis software; Classic apparatus (e.g. Millikan Oil Drop, Ripple Tanks, Michelson Interferometer, Franck-Hertz); TI Graphing calculators; Department website:

http://www.fairfield.k12.ct.us/ludlowehs/cludlowehs26/physicswebsite/index.htm

Overview: The course is conducted within a four marking period school year and meets five times per week. Three of those periods are 45 minute classes, and the other two are 90 minute extended lab periods, resulting in approximately 315 minutes of instructional time per week.

Lecture and discussion are used in conjunction with one another to aid in the development of problem-solving skills, as well as an understanding of the placement of concepts within a theoretical framework, and the historical perspective on the science of physics and experimental science. Guided learning and inquiry, interactive lecture demonstrations, and student-centered instruction, foster the development of critical thinking skills. Developmental problem solving techniques, critical thinking skills, and emphasis on sound experimentation skills are also prominent features of the course.

Students are given the opportunity to investigate fundamental concepts in a laboratory environment through hands-on and student-centered experiments. Two double-lab periods are allotted for lab, and account for over half of the instructional time per week.

Students engage in the setup, development, and conduction of experiments. Students conduct investigations utilizing a wide variety of physical material including standard physics equipment as well as more advanced apparatus such as Michelson Interferometers and Millikan's Oil Drop device. Computer probes and other measuring devices like oscilloscopes and meters are used in the collection of data. Their analysis of data is compiled on-site and worked into comprehensive reports with attention to sound scientific procedures. Students keep a record of their lab work in an appropriate lab notebook.

Laboratory List: Two double-lab periods are allotted for lab, and account for over half of the instructional time per week. The following list includes open-ended investigations, physical law confirmation experiments, measurements of fundamental constants, and practical application of theory.

Newtonian Mechanics

1. Graphical Analysis of Linear Motion: Non-accelerated & Accelerated motion of a student
2. Projectile Targeting: determining angle, range, time-of-flight…

3. Force Table Vector Analysis:resolution and addition of vectors
4. Newton's Second Law: Cart & Hanger: relationship among force, mass, and acceleration
5. Centripetal Force Investigation: relation among force, mass, radius, centripetal acceleration
6. Balancing Torques: relationship between force and radius
7. Momentum Conservation in Collisions & Explosions: conservation principles using carts
8. Collisions in Two Dimensions: vector nature of momentum
9. Work-Power-Energy Measurements
10. Conservation of Energy: Pendulum
11. Hooke's Law & SHM: relationship between force and distance, conservation of energy

Fluid Mechanics & Thermal Physics

1. Archimedes' Principle Investigation: Buoyancy
2. Internal Energy Conservation: Calorimetry
3. Measurement of Specific Heat Ratios (Gamma)

Electricity & Magnetism

1. Ohm's Law: circuit construction, meter measurements
2. Series & Parallel Resistor Combinations: circuit construction, meter measurements
3. Kirchhoff's Laws in Complex Circuits
4. E-Field Mapping: plotting field lines and equipotentials
5. RC-Circuit Behavior
6. q/m ratio of Electron: determining the charge to mass ratio using Thompson tubes and Helmholtz coils
7. Magnetic Field Strength Near Wires: measuring field strength with probes
8. Magnetic Forces: Current Balance
9. Millikan's Oil Drop Experiment: determining the charge on an electron

Waves & Optics

1. Plane & Curved Mirror Image Production: relationship among focal length, image, and object distance
2. Image Production and Geometry of Lens Configurations: relationship among focal length, image, and object distance
3. Determining Refractive Index of Unknown Substance
4. Pulse Behavior in Slinkies: investigating wave properties, reflection, refraction, superposition
5. Wave Phenomena in Ripple Tanks: mechanical wave analogies to behaviors of light, reflection, refraction, diffraction, interference
6. Young's Double Slit: Wavelength of Light measurement

7. Elemental Spectral Analysis with Diffraction Gratings: identifying unknown gas samples
8. Foulcault's Determination of c
9. Holography: create a hologram

Atomic & Nuclear Physics

1. Rutherford Gold-Foil Simulation
2. Michelson Interferometer and the Wavelength of Light measurement
3. Photoelectric Effect & Determination of Planck's Constant
4. Confirmation of Bohr's Hydrogen Energy Levels: measuring the wavelengths of the Balmer series
5. Franck-Hertz Experiment: measuring Planck's constant
6. Measurement of Nuclear Half-life of Radioactive Samples, and the effects of distance and shielding

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Course Outline of Topics

I. <u>Newtonian Mechanics: Solids</u>

a. **Kinematics (4 weeks)**
   - i. Measurement & Units
   - ii. Linear Motion
     1. Galileo's Analysis of Motion
     2. Gravitational Accelerations
     3. Graphical Analysis of Motion
   - iii. Two dimensional linear motion
     1. Vector Analysis
     2. Projectiles

b. **Dynamics (6 weeks)**
   - i. Forces & Free-body Diagrams
   - ii. Linear Motion
     1. Newton's Laws of Motion
     2. Pulley Systems & Atwood's Machine
     3. Friction
   - iii. Two dimensional linear motion
     1. Inclines
     2. Equilibrium
   - iv. Circular Motion & Rotation
     1. Centripetal Force
     2. Centripetal Acceleration

3. Torque

v. Gravitational Dynamics
1. Newton's Law of Gravitation
2. Orbital Motion: Kepler's Laws

vi. Simple Harmonic Motion & Oscillations
1. Springs
2. Pendula

c. **Conservation Laws** **(4 weeks)**

i. Linear Motion
1. Systems of Particles & Collisions
2. Momentum Conservation
3. Energy Conservation
4. Impulse/Momentum Theorem
5. Work/Energy Theorem
6. Power

ii. Two dimensional linear motion
1. Momentum Conservation
2. Energy Conservation

iii. Energy of Gravitational Systems
1. Gravitational Potential
2. Conservation

iv. Energy of Oscillating Systems
1. Springs
2. Pendula

II. Fluid Mechanics & Thermal Physics

a. Liquids **(3 weeks)**

i. Pressure & Buoyancy
1. Gauge Pressure
2. Pascal's Principle
3. Archimedes' Principle

ii. Conservation Laws
1. Bernoulli's Principle

iii. Internal Energy & Calorimetry
1. Temperature
2. Specific Heat Capacity

b. Gases

i. Gas Laws
1. Avagadro's Law

        2. Boyle's Law
        3. Charles' Law
        4. Ideal Gas Law
    ii. Kinetic Theory
        1. Pressure
        2. Sound
        3. Temperature
        4. Heat Capacity
    iii. Heat Engines
        1. pV-diagrams
        2. Carnot Cycles

III. <u>Electrical Physics</u> **(5 weeks)**

- **a. Electrostatics**
    - i. Electrostatic Phenomena
        1. Charged Conductor Effects: Franklin's Analysis
        2. Charge Carriers: Thompson's Discovery
    - ii. Electrical Forces
        1. Force due to Point Charges: Coulomb's Law
    - iii. Electrical Energy
        1. Potential Differences (Voltage)
        2. Potential of Charged Conductors
        3. Capacitors
- **b. Current & Circuitry**
    - i. Ohm's Law
    - ii. Series & Parallel Resistors
    - iii. Kirchhoff's Rules
    - iv. Capacitor Circuits
- **c. Electrical Fields**
    - i. Electrostatic Phenomena
        1. Faraday's Analysis of Conductor Fields
    - ii. Electrical Forces & Field Strength
        1. Field Strength due to Point Charges
    - iii. Electrical Energy & Potential
        1. Field Potential due to Point Charges
        2. Equi-potentials
        3. Capacitor Fields

IV. <u>Magnetic Physics</u> **(3 weeks)**

- **a. Magnetic Matter**

            i. Magneto-static Phenomena
                1. Magnetic Poles: Gilbert's Analysis
                2. Ferromagnetism

b. Magnetic Fields

- i. Particles in Fields: Circular Motion
- ii. Particles in Fields: Lorentz Force
- iii. Motors

c. Electro-magnetic Induction

- i. Generators
- ii. Lenz's Law
- iii. Faraday's Law
- iv. Transformers

V. <u>Special Relativity</u> (1 week)

a. Galilean Relativity

- i. The Principle of Relativity
- ii. Lorentz Transformations

b. Einstein's Theory

- i. Time Dilation
- ii. Length Contraction
- iii. Inertia
- iv. Momentum & Energy
- v. $E = mc^2$

VI. <u>Waves</u> (5 weeks)

a. Mechancial Waves

- i. Huygen's Analysis
- ii. Wave Characteristics
    1. Dimensions
    2. Behavior
- iii. Sound Waves
- iv. Doppler Effect
- v. Superpositioning & Standing Waves

b. Light as a Wave

- i. Electro-magnetic Spectrum
- ii. Law of Reflection
- iii. Refraction
    1. Snell's Law
    2. Total Internal Reflection
    3. Dispersion

4. Polarization & Brewster's Law

iv. Interference

1. Single/Double Slit Patterns
2. Young's Analysis
3. Thin Films

c. Optical Devices

i. Mirrors & Lenses

ii. Diffraction Gratings

iii. Michelson's Analysis: Relativity

VII. <u>Atomic Physics</u> (4 weeks)

a. Quantum Physics: Light as a Particle

i. Photo-electric Effect

ii. Compton Effect

iii. Principle of Complementarity

b. Atomic Theory: Matter as Particles

i. Bragg Diffraction

ii. Subatomic Particles

1. Thompson's Experiments
2. Rutherford's Experiments
3. Bohr's Atomic Theory

c. Quantum Physics: Matter as Waves

i. deBroglie's Theory

ii. Schrodinger's Theory

iii. Heisenberg's Theory

VIII. **Nuclear Physics (3 weeks)**

a. Nuclear Structure & Forces

i. Isotopes

ii. Radioactive Decay

1. Types
2. Half-life
3. Dosimetry

b. Nuclear Energy

i. Binding Energy

1. Nuclear Structure
2. Strong Force
3. $E = mc^2$

ii. Disintegration Energy

iii. Fission & Fusion Processes

IX. **<u>21st Century Physics</u>** **(1 week)**

a. **General Relativity**
b. **Cosmology**
c. **Particle Physics**