Physics/Physics Honors

Course Description

Physicists formulate and test hypotheses based on their observations of the natural world. They use their results to formulate scientific laws expressed in the language of mathematics, and they use these laws to make predictions about other phenomena, from the subatomic to the cosmic. The study of physics includes the study of mechanics, motion, forces, energy, waves, sound, light, electricity, magnetism, atomic structure and nuclear reactions. In this course, students learn the laws and the mathematical language of physics; they use the scientific method to formulate and test hypotheses, analyze data, reason quantitatively, and draw conclusions. They demonstrate their knowledge and skills through a variety of hands-on laboratory activities, classwork, homework, and written assessments. This syllabus defines the course of study for both Physics and Physics Honors. Those learning activities unique to the honors level are labeled as such.

This course teaches and reinforces skills and dispositions aligned with the ***Portrait of the Crusader,*** including thinking critically, solving problems through innovation, and communicating effectively. Laboratory investigations and in-class activities promote collaboration and respect for other student's ideas.

Course Essential Questions

- What is the relationship between matter and energy?
- What underlying forces explain the interactions that we observe in the natural world?
- How are forces related to energy?
- How do we predict an object's continued motion, change in motion, or stability?
- How do we conduct tests of hypotheses in physics?
- What is the intersection between science and mathematics?
- How can rules and relationships be used to predict what will happen in a physical situation?

Course Outline

I. Introduction to Physics

Focus Questions:

- How can we use the scientific method to learn about the physical universe?
- What is a vector vs. a scalar?
- How are systematic observations and measurements made in order to accurately analyze a system?
- What are the fundamental units of measurement?

Concepts/Skills

- Explain and distinguish between scalar and vectors.
- Use scaled diagrams to represent and manipulate vector quantities.
- Make reasonable estimates of metric measurements and convert between metric units.
- Identify significant figures
- Honors: Perform arithmetic calculations and round to the correct number of significant figures.
- Honors: Add vectors, both graphically and mathematically.

Labs:

- Inertia Balance (find unknown masses using an inertia balance)
- Vector Walking
- Mass is Right (classroom challenge)
- Trig It (determine height using inclinometer)

Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit. (Tests are developed based on the course level.)

II. Kinematics

Focus Questions:

- What is kinematics?
- How do graphs help us to understand motion?
- How is an object's motion described by constant changes in position and velocity?
- How can trigonometry and vectors be used to analyze motion in two dimensions?
- How does the acceleration due to gravity near the surface of the earth explain objects in free fall and the motion of projectiles?

Concepts/Skills:

- Define position, velocity, acceleration and kinematics.
- Create and interpret motion graphs.
- Collect and analyze data with precision and accuracy.
- Quantify error in scientific measurements and apply that understanding to the analysis and conclusion of an experiment.
- Perform unit conversions when given the conversion factor.
- Differentiate between distance and displacement, speed and velocity.
- Identify if an object is moving with constant velocity or constant acceleration.
- Analyze the motion of objects that have constant velocity or constant acceleration.
- Add and subtract vector quantities graphically and by components.
- Honors: Determine the x and y components of a vector for an object moving in two dimensions.
- Honors: Analyze the motion of an object in 2-dimensions by resolving vectors into perpendicular component directions.
- Honors: Solve problems involving projectiles, both on paper and in the laboratory
- Honors: Approximate the slope of a curve to calculate instantaneous velocities and accelerations.
- Honors: Derive the equations of motion using the definitions of velocity and acceleration.
- Honors: Apply trigonometry and algebra to solve for unknown quantities in projectile motion problems.
- Honors: Apply the rules of significant digits to all calculations and scientific notation in calculations.

Labs:

- Motion Match
- Reaction Time
- Walk the Walk/Graph the Graph
- Projectile Velocity
- Projectile Cannon Catch

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit. (Tests are developed based on the course level.)

III. Dynamics - Forces and motion

Focus Questions:

- What are the four fundamental forces of nature?
- What are balanced and unbalanced forces?
- What is inertia and how does it affect us in our everyday lives?
- What are centripetal forces and how do they create circular motion?
- Why do astronauts float inside the International Space Station even though the force of gravity on them is nearly the same as on us?

Concepts/Skills:

- Identify individual forces acting on an object and draw an appropriate Free Body Diagram
- Predict an object's motion based on the forces acting on it
- Determine the forces needed to keep a body in a state of static equilibrium.
- Measure and/or calculate the relationship between the net force acting on a body, the mass of the body, and the acceleration produced (Newton's Second Law of Motion).
- Analyze and mathematically describe forces as interactions between bodies (Newton's Third Law of Motion).
- Investigate, measure, and analyze the nature and magnitude of frictional forces.
- Honors: Analyze and mathematically describe centripetal forces that cause circular motion.
- Honors: Explain the relationship between mass, distance and force as described by Newton's Universal Law of Gravity.
- Honors: Apply Newton's Universal Law of Gravity to understand the behavior of both Earthly objects and orbital motion.
- Honors: Apply Newton's Universal Law of Gravity in calculations involving mass, force and distance.
- Honors: Derive and apply formulas for circular satellite motion.

Labs:

- Inertia
- Newton's Second Law (carts, masses, and pulleys)
- Force Table
- Mass of a Car (using a bathroom scale)
- Friction Lab

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit.

IV. Energy

Focus Questions:

- What is a closed system and why is it important to conservation of energy?
- How are force and energy connected?
- What is "useful" energy?
- How do we measure energy? How do we measure energy transfer?
- Where do we observe energy transformations in the real world?

Concepts/Skills:

- Apply the principle of conservation of energy to solve for unknown quantities.
- Categorize all types of energy as either potential or kinetic
- Describe energy transformations in real-life situations.
- Apply concept of energy conservation to simple machines
- Predict the force required to lift or push various loads using different machines.
- Compare the mechanical advantages of different simple machines.
- Formulate methods for lifting large loads with small amounts of force.
- Honors: Measure and analyze the transfer of energy by an applied force using the equation for work.
- Honors: Measure and analyze the rate at which energy is transferred using the equation for power
- Honors: Organize energy types into conservative and non-conservative types.

Labs:

- Energy Transformation in Gadgets
- Power Use (typical American)
- Building the Egyptian Pyramids w/ simple machines.
- Energy Conservation (determine energy conservation when a ball rolls down a ramp)
- Stair Climb (determine how much power one generates running up stairs)

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit. (Tests are developed based on the course level.)

V. Waves and Sound

Focus Questions:

- What is the process that creates and propagates a wave?
- What are the different kinds/types of waves?What are the properties and behaviors of waves?
- Where do we see waves in our everyday lives and why are they important to us?
- How are properties and behaviors of a wave described mathematically?
- Why do different instruments sound differently?
- What technologies make practical use of waves?

- Why does motion affect the perception of a sound wave?

Concepts/Skills:

- Measure/calculate the frequency, period, and wavelength of waves produced in a "Slinky" toy and in a vibrating string.
- Solve wave problems using the wave equation and the relationship between period and frequency.
- Distinguish between and identify transverse and longitudinal waves.
- Describe the root causes of tsunamis.
- Predict the behavior of waves when they encounter barriers.
- Illustrate the behaviors of waves (diffraction, refraction, interference, superposition, Doppler Effect)
- Evaluate and analyze interference patterns of two sets of concentric, two-dimensional waves.
- Experimentally determine the speed of sound using three different methods.
- Explain the causes of a standing wave and identify its parts.
- Explain the phenomenon of resonance and how it impacts our everyday lives.
- Predict the fundamental frequency or harmonics of various musical instruments.
- Analyze the physics of a plucked string using a ukulele.
- Be able to read a sonogram and differentiate between various bird songs.
- Explain how/why a sound source changes apparent pitch when moving relative to the observer.
- Honors: Use the Doppler equation to determine either the shifted frequencies given the motion or the motion given the frequencies.
- Honors: Mathematically relate the amplitude of a wave to its energy/intensity.
- Honors: Derive the equations for the standing waves that are set up in various instruments.

Labs:

- Pendulum Sounds (determine what makes a pendulum tick)
- Slinky Wave Observations
- String Tension
- Ear Structure
- Earthquake Epicenter (determine epicenter of an earthquake geometrically)
- Sonograms and Bird Calls
- The physics of a plucked string (using ukuleles)

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit. (Tests are developed based on the course level.)

VI. Light

Focus Questions:

- What is an electromagnetic wave?
- How do the different regions of the electromagnetic spectrum interact with matter?
- How can one determine the speed of light?
- What is color?
- What is refraction and why is it important?

- How do lenses and curved mirrors cause light to focus or disperse?
- How does the lense of the eye work?

Concepts/Skills:

- Provide evidence that light is a wave. Provide evidence for why light is a particle.
- List, in order, the parts of the electromagnetic spectrum.
- Explain how we use the different parts of the electromagnetic spectrum.
- Explain how we see colors using the concepts of color addition and subtraction.
- Determine the relationship between illumination on an object and the distance from a point light source.
- Explain the phenomenon of light polarization.
- Use the Law of Reflection to control the path of a laser beam with mirrors in a defined field.
- Predict the behavior of light as it passes from one medium into another.
- Determine the focal point of a convex lens.
- Apply the lens law to produce images at predicted distances.
- Draw ray diagrams for both converging and diverging lenses and mirrors.
- Explain how the eyeball captures and focuses light.
- Describe the difference between reflecting and refracting telescopes.
- Explain how fiber optics work and their significance in our everyday lives.
- Honors: Apply Snell's Law to calculate refraction angles in different media.
- Honors: Determine the index of refraction of different substances by measuring apparent depth.
- Honors: Use the Doppler Effect to explain how we know that the universe is expanding.
- Honors: Calculate the power output of the sun using a simple photometer.

Labs:

- Shadow size vs. distance investigation
- Light intensity vs. distance investigation
- Color mixing: differentiate between mixing light and mixing pigments
- Laser Reflection Target Challenge
- Snell’s Law Refraction Target Challenge

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit. (Tests are developed based on the course level.)

VII. Electricity and Magnetism

Focus Questions:

- How does the electromagnetic force compare with the gravitational force?
- How do electrically charged objects interact with each other?
- What are electric fields and electric potential differences?
- Where do we see static electric effects in our everyday lives?
- How are insulators and conductors used?
- How does an electric conductor compare with a thermal conductor?
- How can you describe the flow of electrons through a circuit?

- How are voltage, current, and resistance related in circuits?
- What is the difference in electron flow through a series versus parallel circuit?
- Where do we find plasma?

Concepts/Skills:

- Describe what lightning is and how it forms.
- Explain the relationship between force, charge and distance using Coulomb's law.
- Identify instances of static electrical phenomena in their lives.
- Diagram the shape of an electric field based on a charge distribution.
- Compare and contrast conductors and insulators and describe uses for each.
- Predict/explain the behavior of objects that come in contact with a Van de Graaf generator.
- Demonstrate correct measurements of voltage, current and resistance using a multimeter.
- Illustrate the analogy between water flowing in pipes and electricity flowing in wires.
- Use Ohm's law to evaluate circuits for voltage, resistance and current.
- Apply the power equation (P=IV) to solve problems involving the power consumed by a circuit.
- Calculate the cost of operating various electrical appliances.
- Generate schematic diagrams of simple circuits.
- Explain the relationship between the resistivity of a conductor and both its length and cross sectional area.
- Construct simple circuits, both series and parallel, to light up bulbs.
- Infer the types of circuits found in appliances and houses based on how they are used or operated.
- Generalize how an electric motor operates.
- Explain uses of plasma.
- Honors: Solve problems involving Coulomb's Law.
- Honors: Calculate the induced voltage passing through a transformer.
- Honors: Identify resistors based on their color code.
- Honors: Derive 2 additional power equations using ohm's law and definition of power (P=IV)
- Honors: Solve quantitative problems involving the resistivity of materials of different lengths and cross sectional areas.

Labs:

- Lightning in the classroom: Mini Van de Graaf generator demonstrations
- PHET in the Classroom: Demonstrations of static electricity (virtual lab)
- Resistors and Color Code
- Resistance (how length and cross-sectional area affect resistance)
- Parallel and series circuits (creating and measuring)
- Electrical Motor (build with everyday materials)

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit. (Tests are developed based on the course level.)

VIII. Heat and Thermodynamics (Enrichment: done as time permits)

Focus Questions:

- What is temperature actually measuring?
- Why do certain substances heat up or cool off so much faster than others?
- What is entropy?
- How do the four laws of Thermodynamics govern the movement of heat in the universe?

Concepts/Skills:

- Describe the difference between heat, temperature and thermal energy.
- Use the Fahrenheit, Celsius and Kelvin temperature scales and convert from one to another.
- Define specific heat and calculate heat transfer.
- Categorize various examples of heat transfer as either conduction, convection or radiation.
- Experimentally determine the specific heat of various metals.
- Honors: solve problems concerning the exchanges of heat energy between bodies at different temperatures.
- Solve problems dealing with the molecular kinetic energy and the pressure-volume-temperature relationship of an ideal gas.
- Relate the kinetic theory of matter to the molecular motion of different phases of matter.
- State the second law of thermodynamics and relate it to the operation of a heat engine.
- Identify the various forms of energy (potential, kinetic, thermal, chemical) at work in an internal combustion engine.
- Honors: Quantitatively relate the efficiency of a heat engine to the temperature differences.

Labs:

- Determine the specific heat of various materials.

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit.

IX. Modern Physics (Enrichment: done as time permits)

Focus Questions:

- What are photons?
- What is meant by "wave-particle duality"?
- What is $E = mc^2$?
- How can fusion and fission be used to provide our energy needs?

Concepts/Skills:

- Explain the basic ideas of relativity and quantum mechanics.
- Students will be able to describe the difference between nuclear fission and fusion.
- Students will be able to explain the importance of some of the most influential modern physicists including Einstein, Heisenberg, and Planck.
- Honors: Mathematically calculate length contraction and time dilation as described in Einstein's Theory of Special Relativity.

Labs:

- Modeling nuclear fusion and fission
- Oral presentations on modern physicists

FIeld Trip

- Visit the particle accelerator at Yale University

Summative Assessments:

- Written assessment (unit test) focused on terminology, concepts and modeling taught in the unit.

Resources

- PhET: Free online physics, chemistry, biology, earth science and math simulations." PhET: Free online physics, chemistry, biology, earth science and math simulations. N.p., n.d. Web. 28 June 2011. PhET Simulations
- "The People's Physics Book", The People's Physics Book (CK12 version) by emotif - Issuu
- "Teachers:Lesson Plans." Discovery Education. Web. 29 June 2011. http://www.discoveryeducation.com
- Khan Academy www.khanacademy.org
- Open Stax High School Physics Textbook https://openstax.org/details/books/physics

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Grading Policy

- Summative Assessments - Tests: 35 - 45 %
- Quizzes: 15 - 25 %
- Lab work: 15 - 25 %
- Classwork: 10 - 20 %
- Student Preparation: 15 - 25 %