Greenwich Public Schools Curriculum Overview
Honors Physics

Personalized learning is achieved through standards-based, rigorous and relevant curriculum that is aligned to digital tools and resources.

Note: Teachers retain professional discretion in how the learning is presented based on the needs and interests of their students.

Course Description

Prerequisite: Completion of or concurrent enrollment in Honors Algebra 2 or equivalent; B or better in an Honors Science course or an A in Biology or Chemistry.

This college preparatory course is designed to provide students with an in-depth understanding of the meaning and structure of physics. Through reading, problem solving, laboratory work and individual projects, students will study the principles of motion, forces, energy, optics and light, electricity, magnetism, atomic physics, and nuclear physics. Extensive use will be made of mathematics for analysis of laboratory data, development of physical laws and applications of physics. Project work is an integral part of the course. Students considering taking the SAT Physics subject test should enroll in this course.

Unit Guide

- Theme 1: Forces and Motion
  - Unit 1: 1D Motion
  - Unit 2: Newton's Laws
  - Unit 3: Work, Energy, Power
  - Unit 4: Impulse, Momentum, Collisions
  - Unit 5: Universal Gravitation and Orbits
- Theme 2: Oscillation and Waves
  - Unit 6: Waves Properties and Sound
  - Unit 7: Light and EM Spectrum
- Theme 3: Electricity and Magnetism
  - Unit 8: Electrostatics
  - Unit 9: Electric Current and Circuits
  - Unit 10: Electromagnetism
- Theme 4: Earth and Space Systems
  - Unit 11: The Big Bang
  - Unit 12: Stars and Nucleosynthesis
  - Unit 13: Our Sun and Solar System
  - Unit 14: Earth's History and Core

Enduring Understanding and/or Performance Tasks

- Unit 1: 1D Motion:
  - **Enduring Understandings**
    - When there is a zero net force an object continues its state of motion; When a fixed force is applied to an object its displacement is portional to the time squared

- **Performance Tasks**
  - Express understanding of inertia by identifying real world situations that use the concept of inertia
  - Use tools/technology to collect data that represents the motion of an object over time, and model that data graphically
  - Interpret visual and analytical models of an object's motion in terms of its position, velocity, and/or acceleration with respect to time, and describe the motion in words

➢ Unit 2: Newton's Laws

- **Enduring Understandings**
  - Newton's second law accurately predicts changes in the motion of macroscopic objects
  - Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
  - The acceleration an object can be calculated by using ΣF /m
  - A force exerted on an object is always due to the interaction of that object with another object.
- **Performance Tasks**
  - Generate a model that shows the relationship between force and mass when acceleration is held constant
  - Use tools/technology to verify that the acceleration due to gravity is independent of an object's mass
  - Express the causal relationship between force, mass, and acceleration

➢ Unit 3: Work, Energy, and Power

- **Enduring Understandings**
  - The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted.
  - The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy.
  - The internal energy of a system includes the kinetic energy of its components and the potential energy of the configuration of the objects that make up the system.
  - Power is defined as the rate of energy transfer into, out of, or within a system
- **Performance Tasks**
  - Create a computational model that demonstrates the conservation of energy within a system, and use the model to predict the maximum possible change in energy of a component of the system.
  - Create models to comparatively show the changes in energy of the components of a system at both the microscopic and macroscopic scales (eg. the addition or removal of heat energy can change the average kinetic energy of microscopic particles that compose a macroscopic object, corresponding with the object's change in temperature).
  - Use data/models to show that changes made to components of a closed system may result in no net change to the system's total energy, but can be accounted for by analyzing the resulting net changes to components within the system.
  - Design, build, and test a device (physical or digital) that converts one form of energy into another form of energy, and evaluate its efficiency according to energy inputs vs outputs

➢ Unit 4: Impulse, Momentum, and Collisions

- **Enduring Understandings**
  - The momentum of an object is a product of its mass and velocity and therefore is a vector quantity
  - The change in momentum of that object depends on the impulse, which is the product of the average force and the time interval during which the interaction occurred.
  - The total momentum of a system is constant if not external force is being applied to the system
- **Performance Tasks**
  - Using vector addition, calculate the resultant of a system of interacting objects and make the claim that this value represents the "total momentum" of the system

        - Demonstrate that the total momentum of a system of objects does not change as a result of collisions between objects in the system by computing the total momentum of the system both before and after a collision
        - Demonstrate an understanding of the impulse momentum theorem by building a device that reduces the force of impact during a collision by extending the time over which the impact occurs. Using the test results, improve on the design of the device to achieve a higher efficiency (longer impact time, lower force of impact, etc.)
- ➢ Unit 5: Universal Gravitation and Orbits
    - **Enduring Understandings**
        - Newton's Law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between objects
        - Forces as a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields
        - Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with other objects in the solar system
    - **Performance Tasks**
        - Identify each of the variables in Newton's gravitation equation and the mathematical relationships between them, and use them to predict the units of the gravitational constant, G.
        - Use Newton's Law of Universal Gravitation to correctly predict and explain the force of gravity between two macroscopic objects.
        - Describe the trajectory of an orbital body in terms of its elliptical path
        - Using mathematical or computational models of orbital motion, show that the square of an orbital body's period of revolution is proportional to the cube of the distance between its center and the center of the body it orbits around.
- ➢ Unit 6: Wave Properties and Sound
    - **Enduring Understandings**
        - The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.
        - Classically, the energy carried by a wave depends on and increases with amplitude, which is the maximum displacement of a wave from its equilibrium value
        - For a periodic wave, the period is the repeat time of the wave. The frequency is the number of repetitions of the wave per unit time, and the wavelength is the repeat distance of the wave.
        - The observed frequency of a wave depends on the relative motion of source and observer.
        - Sound waves propagate through traveling disturbance of pressure variations.
        - Standing waves are the result of the addition of incident and reflected waves that are confined to a region and have nodes and antinodes.
        - A standing wave with zero amplitude at both ends can only have certain wavelengths. Examples include fundamental frequencies and harmonics.
    - **Performance Tasks**
        - Model the equation for the speed of a wave mathematically ($v = f \cdot \lambda$), and analyze λf claims that changing one of the variables may only result in a change to one of the others (eg. changing speed and wavelength, but not frequency).
        - Predict these changes in properties of waves in terms of cause (a wave changes the medium through which it travels) and effect (the wavelength changes but not necessarily the frequency
- ➢ Unit 7: Light and EM Spectrum
    - **Enduring Understandings**
        - For propagation, mechanical waves require a medium, while electromagnetic waves (transverse waves) do not require a physical medium.
        - Types of electromagnetic radiation are characterized by their wavelengths
        - When light travels from one medium to another, some of the light is transmitted, some is reflected, and some is absorbed
        - The law of reflection accounts for the size and location of images seen in mirrors.
        - Superposition is when two waves overlap and cause displacement

        - Energy transfer occurs when photons are absorbed or emitted, for example, by atoms or nuclei. An emission spectrum can be used to determine the elements in a source of light.
    - **Performance Tasks**
        - Make a claim that light behaves like a wave using evidence from the double slit experiment
        - Evaluate the claim and reasoning that electromagnetic radiation is both a wave and particle
        - Determine the reliability of the sources of at least two claims of the effect of absorbing radiation into living tissue
        - Use at least two different formats to communicate information about devices that use photoelectric effect to improve society

➢ Unit 8: Electrostatics

- **Enduring Understandings**
    - Like-charged objects and systems repel, and unlike-charged objects and systems attract
    - Electrons have a negative charge, protons have a positive charge. Neutral objects or systems contain equal quantities of positive and negative charge
- **Performance Tasks**
    - Use the variables in Coulomb's Law equation to predict electrostatic force of attraction or repulsion between two charged objects or particles
    - Create models to comparatively show the changes in energy of the components of a system, and that they may result in no net change to the systems total energy
    - Develop a model that represents electric potential energy in space. Use the model to determine the change in energy due to interactions.

➢ Unit 9: Electric Current and Circuits

- **Enduring Understandings**
    - Electric current is the rate at which charges flows past a cross sectional area
    - Current flow requires a conductive loop and a difference in electric potential
    - Matter has a property called resistivity, which depends on the molecular and atomic structure and temperature of the material.
- **Performance Tasks**
    - Describe the power sources as a difference in electric potential energy using a gravitational potential analogy
    - Diagramatically model, construct, and analyze both series and parallel circuits for different applications

➢ Unit 10: Electromagnetism

- **Enduring Understandings**
    - The current induced in a circuit by a changing magnetic flux creates a magnetic field that opposes the change in the magnetic field that created it
    - A magnetic field is a continuous loop, there is no beginning or end
    - Moving electric charge causes a magnetic field in space which direction is defined as the direction of the north pole of a compass
- **Performance Tasks**
    - Conduct an investigation using an electric circuit to collect data and prove that an electric current produces a constant magnetic field, and that a changing magnetic field can produce an electric current
    - Develop a model that shows that charged objects within a field have a direct effect on the shape of the field and the electric potential energy. Use this model to predict interactions

➢ Unit 11: The Big Bang

- **Enduring Understandings**
    - Evidence that the universe is expanding, and the composition of hydrogen and helium supports the big bang theory
    - Nearly all stars and galaxies are red shifted
- **Performance Tasks**
    - Use sources of evidence to construct an explanation for the formation of the universe
    - Use the application of the Doppler Effect to explain why the universe is expanding

- Unit 12: Stars and Nucleosynthesis
  - **Enduring Understandings**
    - Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei involve the release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process
    - The study of stars light spectra and brightness is used to identify the composition of stars, their movements, and their distance from earth
    - Atoms lighter than and including iron are formed at the big bang from nuclear fusion. Heavier elements are produced when stars achieve a supernova stage and explode
  - **Performance Tasks**
    - Create a model that describes nuclear fusion and fission, as well as models for each of the three types of radioactive decay processes.
    - Refine the Big Bang model to include the fusion of light elements that formed in the early universe
    - Make a claim that there is a correlation between a stars mass and stage of development, and how scientists could use this theory to determine a stars composition and motion
- Unit 13: Our Sun and Solar System
  - **Enduring Understandings**
    - There is strong evidence that the planets have migrated from the positions where they were created
    - There is a large range in planets in the levels of: mass, cross sectional diameter, gravitational fields, magnetic fields, number of moons, atmospheric pressure, atmospheric composition, temperature, distance to the sun, and orbital period
    - The theory that planets are created by the star's accretion disc, which explains why planets rotate around a central star in the same direction, in the same plane, and in a similar axial tilt.
  - **Performance Tasks**
    - Develop a model based on evidence of the sun and include the electromagnetic radiation produced by fusion reactions
    - Predict how relative proportions of hydrogen to helium within the sun will change over time
- Unit 14: Earth's History and Core
  - **Enduring Understandings**
    - The surface of the earth is composed of thin plates that interact and move along a mostly solid mantle due to convection currents.
    - The inner core of the earth is solid and the outer core is liquid.
  - **Performance Tasks**
    - Using geological evidence, construct an account of Earth's formation over the first billion years through the Heavy Bombardment period.
    - Develop a model of the components of the Earth's interior based on seismic and magnetic evidence, and describe how continental plates drift over time as a result of convection currents.
    - Analyze and interpret evidence for why the Earth has a relatively powerful and constantly changing magnetic field

Standards

- Vision of the Graduate Standards
  - Pose and pursue substantive questions
    - Ask questions, based on observed phenomena and patterns, that can be answered empirically and distinguish a scientific question from a non-scientific question.
  - Explore, define, and solve complex problems
    - Plan and conduct experimental procedures, identifying relevant variables and collecting appropriate data in order to identify causal relationships and make predictions.
  - Critically interpret, evaluate, and synthesize information

        - Analyze data using mathematics and statistics, to look for patterns or to test whether data are consistent with a hypothesis.
    - Collaborate with others to produce a unified work and/or heightened understanding
        - Use scientific evidence and models to construct explanations of phenomena or solve engineering problems.
    - Communicate effectively for a given purpose
    - Read, evaluate, and produce scientific texts and construct scientific arguments to communicate about science.
- Next Generation Science Standards Performance Expectations
    - Unit 1: 1D Motion
        - PS2-1 N
    - Unit 2: Newton's Forces
        - PS2-1
    - Unit 3: Work, Energy, and Power
        - PS3-1, PS3-2, PS3-3
    - Unit 4: Impulse, Momentum, and Collisions
        - PS2-2, PS2-3
    - Unit 5: Universal Gravitation and Orbits
        - PS2-4, ESS1-4
    - Unit 6: Wave Properties and Sound
        - PS4-1, PS4-2
    - Unit 7: Light and EM Spectrum
        - PS4-3, PS4-4, PS4-5
    - Unit 8: Electrostatics
        - PS2-4, PS3-5
    - Unit 9: Electric Currents and Circuits
        - PS3-2, PS3-5
    - Unit 10: Electromagnetism
        - PS2-5, PS3-5
    - Unit 11: The Big Bang
        - ESS1-2
    - Unit 12: Stars and Nucleosynthesis
        - ESS1-3, PS1-8
    - Unit 13: Our Sun and Solar System
        - PS3-2, ESS1-1
    - Unit 14: Earth's History and Core
        - ESS1-6, ESS2-3

Resources and Assured Experiences

- Textbook:
- Experiment: Rolling object on Flat Surface
- Experiment: Rolling object on fixed ramp
- Experiment: Free Fall Bouncing Ball with Motion Detector
- Inertia Smorgasboard Project
- Pendulum Phet Simulation
- Stacked Ball Bounce Activity
- Doppler Effect Demo
- 3D Standing Wave Machine

- Hydrogen and Helium Spectrum Tubes Experiment
- Double slit experiment
- Electromagnetic Investigation
- Gravity and Orbits Gizmo
- Plate Tectonics Gizmo