Greenwich Public Schools Curriculum Overview

Practical 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 Biology and Chemistry or Practical Chemistry.

This laboratory-oriented course is designed to explore some of the basic principles related to motion, forces, energy, light, electricity, magnetism, and nuclear physics. The study of these principles should enable the student to discover the relationship between many "every-day" experiences and these basic physics principles. This will be done by covering "themes" such as transportation, sports, communications, medicine and home. While algebraic skills are not required, the students should be prepared to work with measurements and numbers on a daily basis. Project work will also be an integral part of the course. Successful completion of this course meets the physical science course requirement for graduation.

Unit Guide

- Theme 1 - Sports
  - Unit 1: 1D Motion
  - Unit 2: Newton's Laws
- Theme 2 - Transportation
  - Unit 3: Impulse, Momentum, Collisions
  - Unit 4: Universal Gravitation and Orbits
- Theme 3 - Medicine
  - Unit 5: Work, Energy, Power
  - Unit 6: Waves Properties and Sound
- Theme 4 - Home
  - Unit 7: Electrostatics
  - Unit 8: Electric Current and Circuits
- Theme 5 - Communication
  - Unit 9: Electromagnetism

- Unit 10: Light and EM Spectrum

➢ Theme 6 - Space

- 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

Theme 1 - Sports

➢ Unit 1: 1D Motion

- **Enduring Understandings**
  - Newton's second law accurately predicts changes in the motion of macroscopic objects

- **Performance Tasks**
  - Express understanding of inertia by identifying real world situations that use the concept of inertia.
  - Interpret visual 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, but it requires revision for subatomic scales or for speeds close to the speed of light.

- **Performance Tasks**
  - Generate a model that shows the relationship between force and mass when acceleration is held constant.
  - Express the causal relationship between force, mass, and acceleration.

Theme 2 - Transportation

➢ Unit 3: Impulse, Momentum, and Collisions

- **Enduring Understandings**

- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- In any system, total momentum is always conserved.
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

- **Performance Tasks**
  - 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 4: 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 distant objects.
  - Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth.
  - Planetary motions around the sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity. These orbits may also change somewhat due to the gravitational effects from, or collisions with, other bodies.
  - 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

Theme 3 - Medicine

➢ Unit 5: Work, Energy, and Power

- **Enduring Understandings**
  - Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.
  - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
  - Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
  - Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
  - That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
  - At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
  - Historically, different units and names were used for the energy present in these different phenomena, and it took some time before the relationships between them were recognized.
  - "Mechanical energy" generally refers to some combination of motion and stored energy in an operating machine.

- **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.
  - 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.

➢ 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. The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties.
  - Resonance is a phenomenon in which waves add up in phase in a structure, growing in amplitude due to energy input near the natural vibration frequency.
  - Structures have particular frequencies at which they resonate. This phenomenon (e.g. waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments.
  - Combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

- **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).

Theme 4 - Home

➢ Unit 7: Electrostatics

- **Enduring Understandings**
  - Forces at a distance are explained by fields permeating space that can transfer energy through space.
  - Force fields (gravitational, electric, and magnetic) contain energy and can transmit energy across space from one object to another.
  - When two objects interacting through a force field change relative position, the energy stored in the force field is changed. Each force between the two interacting objects acts in the direction such that motion in that direction would reduce the energy in the force field between the objects. However, prior motion and other forces also affect the actual direction of motion.

- **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

➢ Unit 8: Electric Current and Circuits

- **Enduring Understandings**
  - The availability of energy limits what can occur in any system.
  - Solar cells are human-made devices that capture the sun's energy and produce electrical energy.
  - "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.
  - All forms of electricity generation and transportation fuels have associated economic, social, and environmental costs and benefits, both short and long term.
  - Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
  - Machines are judged as efficient or inefficient based on the amount of energy input needed to perform a particular useful task. Inefficient machines are those that produce more waste heat while performing a task and thus require more energy input. It is therefore important to design for high efficiency so as to reduce costs, waste materials, and many environmental impacts.

- **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

Theme 5 - Communication

➢ Unit 9: Electromagnetism

- **Enduring Understandings**
  - Magnets or changing electric fields cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
  - Energy can be transferred through in the form of radiation, a phenomenon in which energy stored in fields moves across space.

- **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.

➢ Unit 10: Light and EM Spectrum

- **Enduring Understandings**
  - Electromagnetic radiation (e.g. radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons.
  - The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. Quantum theory relates the two models.
  - Because a wave is not much disturbed by objects that are small compared with its wavelength, visible light cannot be used to see such objects as individual atoms.
  - All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium.
  - When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat).
  - Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
  - Photovoltaic materials emit electrons when they absorb light of a high-enough frequency.
  - Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities.
  - Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.
  - Knowledge of quantum physics enabled the development of semiconductors, computer chips, and lasers, all of which are now essential components of modern imaging, communications, and information technologies.

- **Performance Tasks**

- 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

Theme 6 - Space

➢ Unit 11: The Big Bang

- **Enduring Understandings**
  - The sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe.

- **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**
  - The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
  - Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve changes in nuclear binding energies.
  - The total number of neutrons plus protons does not change in any nuclear process.
  - Strong and weak nuclear interactions determine nuclear stability and processes.
  - Spontaneous radioactive decays follow a characteristic exponential decay law.
  - Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials from the isotope ratios present.
  - Normal stars cease producing light after having converted all of the material in their cores to carbon or, for more massive stars, to iron.
  - Elements more massive than iron are formed by fusion processes but only in the extreme conditions of supernova explosions, which explains why they are relatively rare.

- **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.

        - 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**
    - Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.
    - The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.

- **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**
    - Gradual changes in the shape of Earth's orbit around the sun (over hundreds of thousands of years), together with the tilt of the planet's spin axis (or axis of rotation), have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of climate change, including the relatively recent cycles of ice ages.
    - Although active geological processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.
    - Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust.
    - The top part of the mantle, along with the crust, forms structures known as tectonic plates.
    - Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior.

        - The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.
    - **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.

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
- Unit 2: Newton's Forces
    - PS2-1
- Unit 3: Impulse, Momentum, and Collisions

        - PS2-2, PS2-3
    - Unit 4: Universal Gravitation and Orbits
        - PS2-4, ESS1-4
    - Unit 5: Work, Energy, and Power
        - PS3-1, PS3-2, PS3-3
    - Unit 6: Electrostatics
        - PS2-4, PS3-5
    - Unit 7: Electric Currents and Circuits
        - PS3-2, PS3-3, PS3-5
    - Unit 8: Wave Properties and Sound
        - PS4-1, PS4-2
    - Unit 9: Light and the EM Spectrum
        - PS4-3, PS4-4, PS4-5
    - 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