Greenwich Public Schools Curriculum Overview

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

012250 7 Blocks 1 Credit
Prerequisite: Completion of or concurrently taking Algebra 2A.
Note: NGSS aligned
This college preparatory course is designed to acquaint students with the methods and ideas used by physicists to describe the physical world. With emphasis on laboratory investigation, the basic principles of motion, forces, energy, optics and light, electricity, magnetism, and atomic and nuclear physics will be studied. Mathematics will be used in laboratory data analysis and for the solution of problems. Project work is an integral part of the course.

Unit Guide

- Unit 1: Forces in Motion
  - Module 1: One Dimensional Motion
  - Module 2: Newton's Laws
  - Module 3: Work, Energy and Power
  - Module 4: Impulse, Momentum and Collisions
  - Module 5: Universal Gravitation and Orbits

- Unit 2: Oscillations and Waves
  - Module 1: Wave Properties and Sound
  - Module 2: Light and the EM Spectrum

- Unit 3: Electricity and Magnetism
  - Module 1: Electrostatics
  - Module 2: Electric Current and Circuits
  - Module 2: Electromagnetism

- Unit 4: Earth and Space Systems
  - Module 1: The Big Bang
  - Module 2: Stars and Nucleosynthesis
  - Module 3: Our Sun and Solar Systems
  - Module 4: Earth's History and Core

Enduring Understandings, Performance Tasks and Resources

- Unit 1: Forces in Motion
  - Module 1: One Dimensional 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 PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
    - Anchoring Activities: Motion of an object rolling w/o friction; Motion of an object rolling down fixed ramp

  - Module 2: Newton's Laws
    - Enduring Understandings:
      A system is an object or a collection of objects. Objects are treated as having no internal structure
      On the earth the weight of an object can be calculated by using the equation Fg = mg
      Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
      FBD are useful tools for forces being exerted on an object and writing equations that represent a situation.
      The acceleration an object can be calculated by using F/m

A force exerted on an object is always due to the interaction of that object with another object.

- Performance Tasks: PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. HS-PS2-1
- Anchoring Activities: Modified Atwood machine

- Module 3: Work, Energy and PowerEnduring Understandings
  - 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. Examples include gravitational potential energy, elastic potential energy, and kinetic energy.

    Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects.

    A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces

    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 to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. HS-PS3-1

    Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects). HS-PS3-2

    Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS-PS3-3
  - Anchoring Activities:

    Horizontal mass - spring oscillating system systemPendulum -- oscillating system system

- Module 4: Impulse, Momentum and Collisions
  - <u>Enduring Understandings</u>
    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.
  - <u>Performance Tasks:</u>
    Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. HS-PS2-2
    Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. HS-PS2-3
  - <u>Anchoring Activities:</u>
    Frictionless "cart" to "cart" collision for conservation
    Frictionless "cart" to "wall" collision for impulse momentum

- Module 5: Universal Gravitation and Orbits
  - <u>Enduring Understandings</u>
    Gravitational forces are exerted at all scales and dominate at the largest distances and mass scales.
    Gravitational force describes the interaction of one object with mass with another object with mass. a. The gravitational force is always attractive. b. The magnitude of force between two spherically symmetric objects of mass m1 and m2 is Gm1m2/r2. c. In a narrow range of heights above Earth's surface, the local gravitational field, g, is approximately constant.
    During UCM the direction of the centripetal force and centripetal acceleration are directed inward.
    All planets are modeled by elliptical orbits
    Objects sweep out equal areas in equal time when orbiting a central mass
    T2/a3 is constant for all bodies orbiting the same central mass
  - <u>Performance Tasks:</u>
    Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. HS-PS2-4

- Anchoring Activities:
  Uniform circular motion apparatus 1
  Uniform circular motion apparatus 2

Unit 2: Oscillations and Waves

- Module 1: Wave Properties and Sound
  - Enduring Understandings
    Waves can propagate via different oscillation modes such as transverse and longitudinal.
    The speed of a wave is the product of the wavelength and frequency
    The speed of a wave depends only on properties of the medium.
    The amplitude is the maximum displacement of a wave from its equilibrium value.
    Classically, the energy carried by a wave depends on and increases with amplitude.
    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.
    For a periodic wave, 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. Examples include waves on a fixed length of string and sound waves in both closed and open tubes.
    A standing wave with zero amplitude at both ends can only have certain wavelengths. Examples include fundamental frequencies and harmonics.
    The term first harmonic refers to the standing waves corresponding to the fundamental frequency (i.e., the lowest frequency corresponding to a standing wave). The second harmonic is the standing wave corresponding to the second lowest frequency that generates a standing wave in the given scenario.
    Beats arise from the addition of waves of slightly different frequency.
    Changes in the observed frequency and wavelength of a wave can occur if the wave source and the observer are moving relative to each other.
  - Performance Tasks:

Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-1
PS4-2 Digital vs Analog:
Evaluate questions about the advantages of using a digital transmission and storage of information. HS-PS4-2

- Anchoring Activities:
3D standing wave machine
Doppler effect demo
Long Slinky
Beat Frequency demo

- Module 2: Light and the EM Spectrum
  - Enduring Understandings
For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples include light traveling through a vacuum and sound not traveling through a vacuum
Electromagnetic waves are transverse waves.
The speed (v) of a wave is a product of the wavelength and the frequency. In a vacuum the speed of an electromagnetic wave has a constant value c.
Types of electromagnetic radiation are characterized by their wavelengths, and certain ranges of wavelength have been given specific names. These include (in order of increasing wavelength spanning a range from picometers to kilometers) gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves.
When light travels from one medium to another, some of the light is transmitted, some is reflected, and some is absorbed
When light hits a smooth reflecting surface at an angle, it reflects at the same angle on the other side of the line perpendicular to the surface (specular reflection); this law of reflection accounts for the size and location of images seen in mirrors.
When light travels across a boundary from one transparent material to another, the speed of propagation changes. At a non-normal incident angle, the path of the light ray bends closer to the perpendicular in the optically slower substance. This is called refraction. a. Snell's law relates the angles of incidence b. When light travels from an optically slower substance into an optically faster substance, it bends away from the perpendicular. c. At the

critical angle, the light bends far enough away from the perpendicular that it skims the surface of the material. d. Beyond the critical angle, all of the light is internally reflected.

Relevant Equations: $n = c/v$; $n1 \sin \theta 1 = n2 \sin 2 \theta$

When two waves cross, they travel through each other; they do not bounce off each other. Where the waves overlap, the resulting displacement can be determined by adding the displacements of the two waves. This is called superposition. Examples include interference resulting from diffraction through slits as well as thin-film interference.

When waves pass through an opening whose dimensions are comparable to the wavelength, a diffraction pattern can be observed.

When waves pass through a set of openings whose spacing is comparable to the wavelength, an interference pattern can be observed. Examples include monochromatic double-slit interference.

Energy transfer occurs when photons are absorbed or emitted, for example, by atoms or nuclei. Transitions between two given energy states of an atom correspond to the absorption or emission of a photon of a given frequency (and hence, a given wavelength). An emission spectrum can be used to determine the elements in a source of light.

There is an extensive list of advantages for the digital transmission and storage of information, but there are some advantages of analog formats.

Certain phenomena classically thought of as waves can exhibit properties of particles. The classical models of waves do not describe the nature of a photon. Momentum and energy of a photon can be related to its frequency and wavelength.

- Performance Tasks:

  Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. HS-PS4-3

  Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-4

  Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. HS-PS4-5

- Anchoring Activities:

Hydrogen and Helium Spectrum Tubes

- Unit 3: Electricity and Magnetism
  - Module 1: Electrostatics
    - Enduring Understandings

      For all systems under all circumstances charge is conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.

      There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge. Like-charged objects and systems repel, and unlike-charged objects and systems attract.

      The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge. The magnitude of the elementary charge is equal to 1.6 × 10–19 coulombs. Electrons have a negative elementary charge; protons have a positive elementary charge of equal magnitude, although the mass of a proton is much larger than the mass of an electron.

      Electric force between two charges is portional to the product of those charges and inversely proportional to the distance between the charges. Fg = K q1q2/r2

      The presence of electric charge causes an electric field in space whose direction is defined as the direction a positive test charge would encounter.
    - Performance Tasks:

      Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. HS-PS2-4

      Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. HS-PS3-5
    - Anchoring Activities: None

  - Module 2: Electric Current and Circuits
    - Enduring Understandings

      Matter has a property called resistivity. The resistivity of a material depends on its molecular and atomic structure. The resistivity depends on the temperature of the material.

The resistance of a resistor is proportional to its length and resistivity and inversely proportional to its cross-sectional area.
The equivalent resistor to a series of resistor is the sum of the individual resistors.
The inverse of equivalent resistor to a set of parallel resistor is equal to the sum of the inverse of each of the resistors.
Electric current is the rate at which charge flows flow pass a cross sectional area. $I = q/t$
Current flow in a circuit requires a conductive loop and a difference in electric potential.
The current through a resistor is equal to the electric potential difference across the resistor divided by its resistance.
A parallel plate capacitor creates a constant electric field between the plates by the separation of charge on the two plates. Electrical energy is stored in the electric field of the capacitor.

- <u>Performance Tasks:</u>
  Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). HS-PS3-2
  Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. HS-PS3-5
- <u>Anchoring Activities:</u> None

- Module 2: Electromagnetism
  - <u>Enduring Understandings:</u>
    Ferromagnetic materials contain magnetic domains that are themselves magnets. Magnetic domains can be aligned by external magnetic fields or can spontaneously align.
    Each magnetic domain has its own internal magnetic field, so there is no beginning or end to the magnetic field—it is a continuous loop. If a bar magnet is broken in half, both halves are magnetic dipoles in themselves; there is no magnetic north pole found isolation from a south pole.
    Moving electric charge causes a magnetic field in space who direction is defined as the direction of the north pole of a compass.
    Changing magnetic flux induces an electric field that can establish an induced

emf in a system. More simply stated but less correct is that a changing magnetic field can create a current in an electrical circuit.
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.

- Performance Tasks:
  Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. HS-PS2-5
  Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. HS-PS3-5
- Anchoring Activities:
  Magnetic Projection plates (iron filings to view magnetic field)
  Ring Launcher (ring plus circuit)
  Hand Crank Generators

- Unit 4: Earth and Space Systems
  - Module 1: The Big Bang
    - Enduring Understandings:
      Nearly all stars and galaxies are red shifted
      Evidence that the universe is expanding supports the big bang theory
      The composition of hydrogen and helium support the big bang theory
      The omni-directional nature of the CMB was predicted to exist as evidence of the big bang theory and then subsequently observed
    - Performance Tasks: ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
    - Anchoring Activities: Gizmos: Big Bang Theory - Hubble's Law
  - Module 2: Stars and Nucleosynthesis
    - Enduring Understandings:
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      Evidence that the universe is expanding supports the big bang theory
      The composition of hydrogen and helium support the big bang theory
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- Performance Tasks: ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements. PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. HS-PS1-8
- Anchoring Activities: Gizmos: HR Diagrams; Nuclear Reactions

- Module 3: Our Sun and Solar Systems
  - Enduring Understandings:
    The solar system is dominated by space which is often not represented by visual models that typical break scales to show all the components of the of the solar system
    There is strong evidence that the planets have migrated from the positions where they were created
    There is a large range in the level of the following quantities in planets and understanding these quantities helps creates a model of the environment in, on and near each planet: mass, cross sectional diameter, gravitational fields, magnetic fields, number of moons, atmospheric pressure, atmospheric composition, temperature,distance to the sun and orbital period
    There are several modes of planetary motion that are explained by the theory that the planets are created by the star's accretion disk. This includes the fact that planets typically rotate around a central star in the same direction and in the same plane and a similarity of axial tilt and direction.
  - Performance Tasks:
    Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). HS-PS3-2
    ESS1-1 The Sun:
    Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. HS-ESS1-1
  - Anchoring Activities: NONE

- Module 4: Our Earth and its Core
  - Enduring Understandings:
    The Earth's surface we live on is comprised of extremely thin plates that "float" on a mostly-solid mante.

The plates of the earth interact

The mantle lies between Earth's dense, super-heated core and its thin outer crust layer.

The earth's inner core is solid and its outer core is liquid.

The earth's outer core is liquid.

Convection currents in the outer core are thought to be the source of Earth's EM field

The magnetic field of the earth allows the retention of our atmosphere which is critical to life as we know it

One of the reasons the earth's surface continually regenerate is through plate tectonics

- <u>Performance Tasks:</u>

  Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. HS-ESS1-6

  Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS2-3

- <u>Anchoring Activities:</u>

  Motion of an object with balanced forces

  Motion of an object with a fixed force

Standards

➢ <u>Vision of the Graduate Standards</u>

- 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 int erpret, 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.