Curriculum Development
In the Fairfield Public Schools

Fairfield Public Schools
Fairfield, Connecticut

PHYSICS 40

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PHYSICS 40

Statement of Purpose

Physics is the study of matter and energy, and their interactions. As one of the fundamental sciences, physics describes the processes that involve everything from atoms to the universe. The laws that govern the interactions of matter and energy are the laws that govern the everyday occurrences such as those we experience as we drive a car or listen to a CD. In this course, students will investigate the fundamentals of physics and learn how they relate to their everyday lives. Emphasis will be placed on laboratory experiments and "real world" application.

Audience

Physics 40 is a full-year, two-credit course designed for grade 11 or 12 students with good problem-solving ability and an interest in science.

Prerequisites

"C" or better in each of the following courses: Algebra I, Geometry, Chemistry 31 or 32

Design and Description

This course will provide students with a fundamental knowledge of physics. Some of the areas studied include: motion and forces, conservation of energy and momentum, waves, heat and thermodynamics, and electricity and magnetism. The emphasis is on basic concepts, analysis of laboratory data and problem solving. Students in Physics 40 will develop problem-solving abilities. Students will investigate these topics through a variety of classroom activities which include: pre-written and open-ended laboratory experiments; small group discussions; lectures and note taking; viewing videos; learning and applying problem-solving techniques; and relating physics principles to daily experience. Students will understand the role of physics in explaining natural phenomena and in seeking solutions to scientific and technological problems that citizens of the 21st century will face.

Course Objectives

Students will be able to:

- discuss specular vs. diffuse reflection.
- distinguish between real and virtual images.
- explain wave behaviors such as Reflection, Refraction, Diffraction, and Interference.
- describe Refraction and what happens to a light ray as it passes from one medium into another.
- use the Index of Refraction to solve related problems.
- apply Snell's Law of refraction to solve related problems.
- describe causes and practical applications of phenomena such as Dispersion and Total Internal Reflection.
- discuss the characteristics of sound waves such as: require a medium, speed in medium is temperature dependent, intensity and intensity level, refraction, Doppler effect.
- discuss the concepts of phase and phase difference.
- explain the phenomenon of beats in terms of the superposition of waves.
- describe the relationship between nodes and antinodes, and standing waves.
- explain the concept of resonance.

- apply superposition and interference to waves.
- discuss the uses of diffraction gratings.
- explain the difference between Position, Distance, and Displacement.
- differentiate between Speed and Velocity.
- describe the difference between Constant, Average, and Instantaneous velocity.
- differentiate between Velocity and Acceleration.
- differentiate between Scalar and Vector quantities.
- choose proper sign conventions for direction of motion (+,-).
- define Force, Mass, Weight, and Inertia.
- differentiate between Mass and Weight.
- explain Newton's Laws of Motion.
- identify Action-Reaction force pairs.
- identify frictional forces and explain their importance.
- define equilibrium and solve related problems.
- explain the connection between gravitational force and weight.
- compare and contrast uniform circular motion, to linear motion.
- describe the concept of centripetal acceleration.
- describe the roles of force and inertia in centripetal motion.
- explain that Impulse and Momentum are vector quantities.
- relate the Impluse-Momentum Theorem to Newton's Laws.
- verify that linear momentum is conserved in both elastic and inelastic collisions.
- investigate the conservation of kinetic energy in collisions.
- differentiate among different forms of energy.
- verify that the work done depends only upon the force and displacement, and not the path taken.
- explain that the work done changes the energy of the object.
- define Power as the rate at which work is done.
- explain that charge is conserved and quantized.
- differentiate between electrical Conductors and Insulators.
- demonstrate how objects can be charged by conduction and induction.
- demonstrate that like charges repel and opposites attract.
- apply the concept of an Electric Field created by a point charge to.
- describe the concept of electromotive force.
- define electric current.
- differentiate between the concepts of voltage, current and resistance.
- explain the process of energy transfer via.
- demonstrate and explain the function of a Voltmeter, Ammeter, Galvanometer, etc.
- differentiate among the several kinds of magnets: Permanent, Temporary, and Electromagnets.
- compare and contrast Electrical Fields and Magnetic Fields.
- discuss applications of magnetism (recording, maglev, speakers, etc).
- identify applications of magnetism and electromagnetic induction (generators, transformers).
- explain the relationship between current and magnetism.

- conclude that an electromagnetic wave (light) is composed of electric and magnetic fields that oscillate.

Skill Objectives

Students will:

- define a wave as a disturbance that carries energy from place to place.
- discuss the difference between a transverse and longitudinal wave.
- define wavelength, period, cycle, phase, amplitude, and frequency.
- articulate the relationship between wavelength, frequency, and speed of a wave.
- show that light can be considered an electromagnetic wave with a frequency, wavelength, and speed (c).
- show through ray diagrams the concepts of wave front for spherical and plane waves.
- draw ray diagrams for plane mirrors and find images.
- draw ray diagrams for curved mirrors and locate images. Identify the “cases” for mirrors.
- apply the Mirror Equation and Magnification Equation to solve related problems and locate images.
- draw ray diagrams for refracted rays.
- apply the Thin Lens Equation and Magnification Equation to solve related problems and locate images.
- draw superposed waves through constructive/destructive interference.
- construct and analyze displacement-time, velocity-time, and acceleration-time graphs.
- collect data and apply graphical analysis techniques to understand and solve kinematics problems in one dimension.
- use the Kinematics Equations for one dimensional motion with constant acceleration to solve related problems.
- use the independence of motion in each direction (x, y) to solve problems in two dimensions.
- draw a Free Body Diagram to solve problems.
- solve problems relating force, mass, and acceleration.
- solve related problems and applications involving circular motion.
- use Newton’s Law of Universal Gravitation to solve related problems.
- apply the Work-Energy Theorem to solve related problems.
- apply the principles of Conservation of Energy to solve related problems.
- apply the principle of Conservation of Momentum for a system of objects to solve problems.
- sketch Electric Field Lines and Equipotential Lines for an arrangement of charges or devices.
- solve problems using Coulomb’s Law.
- calculate the forces experienced by a test charge in an electric field.
- solve related problems using Ohm’s Law.
- apply P=IV to show that energy is transferred at a given rate.
- calculate the equivalent resistance (R_{eq}) electrical circuits.
- show that opposite poles attract, and like poles repel.
- show the interactions between magnetic fields and currents.

- apply the rules for magnetic fields (i.e. direction of lines, magnitude, never cross, etc).

<u>Physics Enrichment Standards</u>

Waves

Waves have characteristic properties that do not depend on the type of wave.

Waves carry energy from one place to another.

Transverse and longitudinal waves exist in mechanical media, such as springs and ropes, and in the earth as seismic waves.

Wavelength, frequency, and wave speed are related.

Sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.

Radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8m/s, and less when passing through other media.

Waves have characteristic behaviors such as interference, diffraction, refraction and polarization.

Beats and the Doppler Effect result from the characteristic behavior of waves.

Motion and Forces

Newton's laws predict the motion of most objects.

When forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest.

The law $F = ma$ is used to solve motion problems that involve constant forces.

When one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction.

Applying a force to an object perpendicular to the direction of its motion causes the object to change direction.

Circular motion requires the application of a constant force directed toward the center of the circle.

Conservation of Energy and Momentum

The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.

Kinetic energy can be calculated by using the formula E = (1/2) mv2.

Changes in gravitational potential energy near Earth can be calculated by using the formula (change in potential energy) = *mgh.*

Momentum is calculated as the product *mv*.

Momentum is a separately conserved quantity different from energy.

An unbalanced force on an object produces a change in its momentum.

The principles of conservation of momentum and energy can be used to solve problems involving elastic and inelastic collisions.

Electric and Magnetic Phenomena
Electric and magnetic phenomena are related and have many practical applications.

The voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors can be predicted using Ohm's law.

Any resistive element in a DC circuit dissipates energy, which heats the resistor.

The power in any resistive circuit element can be calculated by using the formula Power = 1^2R.

Charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

Magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

Changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

Information and Technology Standards (to be added)

Essential Question

- What is the role of energy in our world?

Focus Questions

- How does light behave and what are its properties?
- How are images formed by mirrors?
- How does light behave as it passes from one medium into another?
- How are images formed by lenses?
- How do waves interact with one another?
- How are displacement, velocity, and acceleration related?
- How do we describe the motion of an object?
- What is the nature of vectors and how do they differ from scalar quantities?

- How does gravity influence the motion of a projectile?
- How do we describe the motion of an object?
- How are Newton’s Laws used to describe motion?
- How does circular motion differ from linear motion?
- How does the Law of Universal Gravitation govern the interaction of objects in the universe?
- How do we describe the motion of an object?
- How are impulse and momentum related?
- How does the law of conservation of momentum (in a closed system) apply to collisions and explosions?
- What is the relationship between work and energy?
- How is energy transformed from one type into another?
- What makes objects move the way they do?
- What is the nature of the electric force?
- How is charge formed/transferred?
- How does Coulomb’s Law explain the force between charged particles?
- What are the properties of an electric field?
- How is the electric field similar to the gravitational field?
- What is the relationship among current, voltage, and resistance?
- What is the nature of the magnetic force?
- What is the relationship between electricity and magnetism?

UNITS of STUDY

Unit 1: Waves and Optics - Reflection

Physics Enrichment Standards
Waves
Waves have characteristic properties that do not depend on the type of wave.

Waves carry energy from one place to another.

Transverse and longitudinal waves exist in mechanical media, such as springs and ropes, and in the earth as seismic waves.

Wavelength, frequency, and wave speed are related.

Radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8m/s, and less when passing through other media.

Essential Question
What is the role of energy in our world?

Focus Questions
- How does light behave and what are its properties?
- How are images formed by mirrors?

Core Topics
- Electromagnetic spectrum (c, λ, ν)
- Reflection (plane and curved mirrors) images.

Unit Objectives
Students will be able to:
- discuss specular vs. diffuse reflection.
- distinguish between real and virtual images.
- explain wave behaviors such as Reflection, Refraction, Diffraction, and Interference.

Skill Objectives
Students will:
- define a wave as a disturbance that carries energy from place to place.
- discuss the difference between a transverse and longitudinal wave.
- define wavelength, period, cycle, phase, amplitude, and frequency.
- articulate the relationship between wavelength, frequency, and speed of a wave.
- show that light can be considered an electromagnetic wave with a frequency, wavelength, and speed (c).
- show through ray diagrams the concepts of wave front for spherical and plane waves.

- draw ray diagrams for plane mirrors and find images.
- draw ray diagrams for curved mirrors and locate images. Identify the “cases” for mirrors.
- apply the Mirror Equation and Magnification Equation to solve related problems and locate images.

Sample Assessments

- Locating images in plane mirrors
- Locating images in curved mirrors

Pacing

3 weeks

Unit 2: Waves and Optics - Refraction

Physics Enrichment Standard

Waves

Waves have characteristic properties that do not depend on the type of wave.

Waves have characteristic behaviors such as interference, diffraction, refraction and polarization.

Essential Question

What is the role of energy in our world?

Focus Questions

- How does light behave as it passes from one medium into another?
- How are images formed by lenses?

Core Topics

- Snell's Law
- Lenses

Unit Objectives

Students will be able to:

- describe Refraction and what happens to a light ray as it passes from one medium into another.
- use the Index of Refraction to solve related problems.
- apply Snell's Law of refraction to solve related problems.
- describe causes and practical applications of phenomena such as Dispersion and Total Internal Reflection.

Skill Objectives

Students will:

- draw ray diagrams for refracted rays.
- apply the Thin Lens Equation and Magnification Equation to solve related problems and locate images.

Sample Assessment

Determining the index of refraction (Snell's law)

Pacing

2.5 weeks

Unit 3: Waves and Optics - Interference

Physics Enrichment Standard
Waves
Waves have characteristic properties that do not depend on the type of wave.

Sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.

Waves have characteristic behaviors such as interference, diffraction, refraction and polarization.

Beats and the Doppler Effect result from the characteristic behavior of waves.

Essential Question
What is the role of energy in our world?

Focus Question
How do waves interact with one another?

Core Topics
- Wave phenomena
- Superposition

Unit Objectives
Students will be able to:
- discuss the characteristics of sound waves such as: require a medium, speed in medium is temperature dependent, intensity and intensity level, refraction, Doppler effect.
- discuss the concepts of phase and phase difference.
- explain the phenomenon of beats in terms of the superposition of waves.
- describe the relationship between nodes and antinodes, and standing waves.
- explain the concept of resonance.
- apply superposition and interference to waves.
- discuss the uses of diffraction gratings.

Skill Objective
Students will:
- draw superposed waves through constructive/destructive interference.

Sample Assessments
- Spring Lab
- Wavelength Analysis

Pacing
2.5 weeks (end marking period #1)

Unit 4: Mechanics - Motion and Forces - Kinematics

Physics Enrichment Standard
Motion and Forces
Newton's laws predict the motion of most objects.

When forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest.

The law $F = ma$ is used to solve motion problems that involve constant forces.

Applying a force to an object perpendicular to the direction of its motion causes the object to change direction.

Essential Question
What is the role of energy in our world?

Focus Questions
- How are displacement, velocity, and acceleration related?
- How do we describe the motion of an object?
- What is the nature of vectors and how do they differ from scalar quantities?
- How does gravity influence the motion of a projectile?
- How do we describe the motion of an object?

Core Topics
- Motion in one dimension (d, v, a)
    - Graphical analysis (data acquisition and analysis)
- Vector Solutions
    - Graphical (scale diagram)
    - Mathematical (trigonometry)
- Projectiles

Unit Objectives
Students will be able to:
- explain the difference between Position, Distance, and Displacement.
- differentiate between Speed and Velocity.
- describe the difference between Constant, Average, and Instantaneous velocity.
- differentiate between Velocity and Acceleration.
- differentiate between Scalar and Vector quantities.
- choose proper sign conventions for direction of motion (+,-).

Skill Objectives
Students will:
- construct and analyze displacement-time, velocity-time, and acceleration-time graphs.

- collect data and apply graphical analysis techniques to understand and solve kinematics problems in one dimension.
- use the Kinematics Equations for one dimensional motion with constant acceleration to solve related problems.
- use the independence of motion in each direction (x, y) to solve problems in two dimensions.

Sample Assessments

- Graphical Analysis of linear motion
- Projectile targeting

Pacing

3.5 weeks

Unit 5: Mechanics - Motion and Forces - Dynamics, Circular Motion and Gravitation

Physics Enrichment Standard

Motion and Forces

The law $F = ma$ is used to solve motion problems that involve constant forces.

When one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction.

Circular motion requires the application of a constant force directed toward the center of the circle.

Essential Question

What is the role of energy in our world?

Focus Questions

- How are Newton's Laws used to describe motion?
- How does circular motion differ from linear motion?
- How does the Law of Universal Gravitation govern the interaction of objects in the universe?
- How do we describe the motion of an object?

Core Topics

- Newton's Laws
- Friction
- Centripetal force
  - Law of Universal Gravitation
  - Kepler's Laws, orbits

Unit Objectives

Students will be able to:

- define Force, Mass, Weight, and Inertia.
- differentiate between Mass and Weight.
- explain Newton's Laws of Motion.
- identify Action-Reaction force pairs.
- identify frictional forces and explain their importance.
- define equilibrium and solve related problems.
- explain the connection between gravitational force and weight.
- compare and contrast uniform circular motion, to linear motion.
- describe the concept of centripetal acceleration.
- describe the roles of force and inertia in centripetal motion.

Skill Objectives

Students will:

- draw a Free Body Diagram to solve problems.
- solve problems relating force, mass, and acceleration.
- solve related problems and applications involving circular motion.
- use Newton’s Law of Universal Gravitation to solve related problems.

Sample Assessment
- Inclined plane and the force of friction
- Centripetal motion

Pacing
4.5 weeks (mid year exam point)

Unit 6: Mechanics - Motion and Forces - Conservation Laws

Physics Enrichment Standards

Conservation of Energy and Momentum

The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.

Kinetic energy can be calculated by using the formula E = (1/2) mv2.

Changes in gravitational potential energy near Earth can be calculated by using the formula (change in potential energy) = *mgh.*

Momentum is calculated as the product *mv*.

Momentum is a separately conserved quantity different from energy.

An unbalanced force on an object produces a change in its momentum.

The principles of conservation of momentum and energy can be used to solve problems involving elastic and inelastic collisions.

Essential Question

What is the role of energy in our world?

Focus Questions

- How are impulse and momentum related?
- How does the law of conservation of momentum (in a closed system) apply to collisions and explosions?
- What is the relationship between work and energy?
- How is energy transformed from one type into another?
- What makes objects move the way they do?

Core Topics

- Conservation
    - Momentum
    - Work-Energy Theorem
    - Kinetic, Potential, Heat
- Collisions
- Explosions

Unit Objectives

Students will be able to:

- explain that Impulse and Momentum are vector quantities.
- relate the Impluse-Momentum Theorem to Newton's Laws.
- verify that linear momentum is conserved in both elastic and inelastic collisions.
- investigate the conservation of kinetic energy in collisions.

- differentiate among different forms of energy.
- verify that the work done depends only upon the force and displacement, and not the path taken.
- explain that the work done changes the energy of the object.
- define Power as the rate at which work is done.

Skill Objectives

Students will:

- apply the Work-Energy Theorem to solve related problems.
- apply the principles of Conservation of Energy to solve related problems.
- apply the principle of Conservation of Momentum for a system of objects to solve problems.

Sample Assessment

Conservation of momentum in a collision, an explosion, and through change of mass

Pacing

4.5 weeks

Unit 7: Electricity and Magnetism - Static Electricity

Physics Enrichment Standard
Electric and Magnetic Phenomena
Electric and magnetic phenomena are related and have many practical applications.

Charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

Essential Question
What is the role of energy in our world?

Focus Questions
- What is the nature of the electric force?
- How is charge formed/transferred?
- How does Coulomb's Law explain the force between charged particles?
- What are the properties of an electric field?
- How is the electric field similar to the gravitational field?

Core Topics
- Charges
- Coulomb's Law
- Fields

Unit Objectives
Students will be able to:
- explain that charge is conserved and quantized.
- differentiate between electrical Conductors and Insulators.
- demonstrate how objects can be charged by conduction and induction.
- demonstrate that like charges repel and opposites attract.
- apply the concept of an Electric Field created by a point charge to.

Skill Objectives
Students will:
- sketch Electric Field Lines and Equipotential Lines for an arrangement of charges or devices.
- solve problems using Coulomb's Law.
- calculate the forces experienced by a test charge in an electric field.

Sample Assessment
Electric field mapping

Pacing
3.5 weeks (end marking period #3)

Unit 8: Electricity and Magnetism - Current Electricity

Physics Enrichment Standard
Electric and Magnetic Phenomena
Electric and magnetic phenomena are related and have many practical applications.

The voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors can be predicted using Ohm's law.

Any resistive element in a DC circuit dissipates energy, which heats the resistor.

The power in any resistive circuit element can be calculated by using the formula Power = 1^2R.

Essential Question
What is the role of energy in our world?

Focus Question
What is the relationship among current, voltage, and resistance?

Core Topics
- Electrical potential
    - Voltage, current, resistance
    - Circuits
- Ohm's Law

Unit Objectives
Students will be able to:
- describe the concept of electromotive force.
- define electric current.
- differentiate between the concepts of voltage, current and resistance.
- explain the process of energy transfer via.
- demonstrate and explain the function of a Voltmeter, Ammeter, Galvanometer, etc.

Skill Objectives
Students will:
- solve related problems using Ohm's Law.
- apply P=IV to show that energy is transferred at a given rate.
- calculate the equivalent resistance (R_{eq}) electrical circuits.

Sample Assessment
Determining current, voltage, and resistance in a circuit

Pacing
4 weeks

Unit 9: Electricity and Magnetism - Magnetism

Physics Enrichment Standard

Electric and Magnetic Phenomena

Electric and magnetic phenomena are related and have many practical applications.

Magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

Changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

Essential Question

What is the role of energy in our world?

Focus Questions

- What is the nature of the magnetic force?
- What is the relationship between electricity and magnetism?

Core Topics

- Magnetic Fields
- Magnetic Forces
- Electromagnetism

Unit Objectives

Students will be able to:

- differentiate among the several kinds of magnets: Permanent, Temporary, and Electromagnets.
- compare and contrast Electrical Fields and Magnetic Fields.
- discuss applications of magnetism (recording, maglev, speakers, etc).
- identify applications of magnetism and electromagnetic induction (generators, transformers).
- explain the relationship between current and magnetism.
- conclude that an electromagnetic wave (light) is composed of electric and magnetic fields that oscillate.

Skill Objectives

Students will:

- show that opposite poles attract, and like poles repel.
- show the interactions between magnetic fields and currents.
- apply the rules for magnetic fields (i.e. direction of lines, magnitude, never cross, etc).

Sample Assessment

Mapping magnetic fields

Pacing

4 weeks