Physics First

Grades 9-12

<u>Curriculum Committee Members</u>

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Hazelwood School District

Mission Statement

We are a collaborative learning community guided by a relentless focus to ensure each student achieves maximum growth

Vision Statement

HSD will foster lifelong learners, productive citizens, and responsible leaders for an ever-evolving society.

Board of Education on January 5, 2010

Goals

Goal #1: Hazelwood students will meet or exceed state standards in all curricular area with emphasis in reading, writing, mathematics, science and social studies.

Goal #2: Hazelwood staff will acquire and apply skills necessary for improving student achievement.

Goal #3: Hazelwood School District, the community, and all families will support the learning of all children.

Curriculum Overview

According to the American Association of Physics Teachers (AAPT), in order for students to truly gain an understanding of the molecular nature of biology and biochemical processes in cells, as well as the abstract nature of chemistry, it is necessary for students to have a basic understanding of physics, the foundational science.

> "Physics First" is a movement that encourages high schools to offer a full-year physics course to ninth-graders, before they take chemistry and biology. Also sometimes called "early high school physics," the "physics-chemistry-biology (PCB)" sequence, or the "cornerstone to capstone (C-to-C) program," Physics First has been gaining momentum as an organized movement of educators and physicists since around 1990, although the concept of teaching physics to ninth-graders goes back several decades before that. Nobel Prize-winning physicist Leon Lederman, Physics First's most prominent proponent, estimates that around 2,000 US high schools have now adopted some version of the program for at least some of their freshmen.
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> \- APS News, 2009

Physics is the branch of science which studies the relationships between matter and energy. Topics that are discussed in this course include mechanics, thermodynamics, wave phenomena, optics, electricity, magnetism, atomic structure, relativity, and how these principles affect our society and the world as a whole. A knowledge and understanding of the principles of physics not only leads to a profound understanding of the physical world, but also supplies the student with the insight to develop new and innovative ideas.

Main Goals:

At the end of this course the students will be able to:

- Discuss science as a body of knowledge and an investigative process.
- Understand that science is a way of knowing and that technology is a way of adapting
- Conduct scientific investigations systematically.
- Organize and interpret Graphs and Tables to express patterns and relationships.
- Apply appropriate units, significant figures and algebraic expressions in measurements and calculations.
- Understand the role, place, and interactions of matter and energy in the universe.
- Understand the characteristics that are unique to mechanics, heat, electricity, magnetism, and atomic phenomena.
- Use written and oral communication skills to explain scientific phenomena and concepts in an appropriate manner.

Popkin, Gabriel. (July 2009). "Physics First" Battles for Acceptance. *American Physics Society, Volume 8* (7). Retrieved from https://www.aps.org

COURSE TITLE: Physics First

GRADE LEVEL: 9^{th} – 12^{th}

CONTENT AREA: High School Science

Course Description:

Physics First emphasizes the science behind real world applications of electricity, motion, forces, and energy. The force and motion units will include velocity, acceleration, and Newton's Laws. Hands-on explorations using math and technology are incorporated to gain well-rounded knowledge of science concepts. Students will build scientific models to describe the physical world. Lab activities are designed to develop skills in experimental design and data analysis. The first semester introduces the study of electricity and principles of motion. The second semester delves into forces, energy and waves. A variety of hands-on laboratory activities will be included.

Course Rationale:

The physics course builds on students' knowledge and skills developed throughout 8^{th} grade mathematics and middle school physical science. A knowledge and understanding of physics often provides the unifying link between interdisciplinary studies. The study of physics provides the foundation knowledge and skills required to support participation in a range of careers. It is a discipline that utilizes innovative and creative thinking to address new challenges, such as energy efficiency and the creation of new materials.

Course Scope and Sequence	
First Semester	
Unit 1: Scientific Method/Introduction to Electricity (7 – 90 minute class periods)	Unit 2: Electric Circuits (13 – 90 minute class periods)
Unit 3: Uniform Motion (13 – 90 minute class periods)	Unit 4: Accelerated Motion (12 – 90 minute class periods)
Second Semester	
Unit 5: Forces and Newton's Laws (10 – 90 minute class periods)	Unit 6: Momentum (8 – 90 minute class periods)
Unit 7: Energy (14 – 90 minute class periods)	Unit 8: Waves (13 – 90 minute class periods)

Proposed Course Materials and Resources:

Exploring Physics Curriculum (University of Missouri –Columbia)
Physics Lab Resources

Essential Terminology/Vocabulary
Unit 1: Battery, bulb, charge, circuit, closed (circuit), conductor, current, electrodes, electrolytes, engineering process, insulator, open (circuit), resistance, schematic diagram, switch, and voltage. Unit 2: Battery, bulb, charge, circuit, closed (circuit), conductor, current, electrodes, electrolytes, insulator, open (circuit), resistance, resistivity, schematic diagram, series (circuit), parallel (circuit), switch, and voltage. Unit 3: Displacement, distance, frame of reference, kinematics, magnitude, motion maps (or motion diagrams), scalar, time, trend line (or line of best fit), and vector. Unit 4: Acceleration, acceleration due to gravity, control, dependent variable, displacement, distance, frame of reference, independent variable, kinematics, magnitude, mathematical representations, motion maps (or motion diagrams), scalars, tangent line, trend line (or line of best fit), time, vectors, and velocity. Unit 5: Acceleration, acceleration due to gravity, action-reaction (or action force and reaction force), balanced (equilibrium), coefficient of friction, components, displacement, distance, force (or free body) diagrams, friction, inertia, mass, mathematical representations, motion maps (or motion diagrams), net force, normal (force), scalars, static(s), tension, time, vectors, velocity, and weight. Unit 6: Conservation of momentum, elastic collision, explosions, impulse, impulse-momentum theorem, inelastic collision, and momentum. Unit 7: Acceleration due to gravity, chemical potential energy, conservation of energy, elastic potential energy, dissipated energy, gravitational potential energy, height, Hooke's law, kinetic energy, mass, spring (force) constant, stretch, time, velocity, and weight. Unit 8: Amplitude, antinode, closed pipe, constructive interference, destructive interference, electromagnetic wave, fixed-end, free-end, linear density, light, longitudinal, media, node, open pipe, period, pitch, pulse, resonance, sound, standing wave, transverse, wave, wave speed, and wavelength.

Unit Objectives:

Unit 1:

1. I can design a tower using spaghetti that holds a marshmallow.
2. I can determine properties of water and alcohol by experimentation.
3. I can describe types of electrical charges and their interactions.
4. I can describe how electrical devices work.
5. I can identify the contact points for batteries, bulbs, and switches.
6. I can explain how batteries, bulbs, and switches work.
7. I can distinguish between open and closed circuits.
8. I can provide evidence that current flows in a specific direction.
9. I can use a multi-meter to measure current, voltage and resistance
10. I can create a verbal, schematic, or pictorial description of a physical electrical circuit.
11. I can construct an electrical circuit from the verbal, schematic, or pictorial representation of a circuit.
12. I can define voltage and measure a battery's voltage.
13. I can identify the essential components of a wet-cell battery.
14. I can construct batteries using different combinations of electrodes and electrolytes.
15. I can measure the voltage of the batteries constructed.

Unit 2:

1. I can compare and contrast a one-bulb circuit and a two-bulb series circuit.
2. I can define current, voltage and resistance.
3. I can measure the current throughout a series circuit.
4. I can measure the voltage of the battery and across each resistor in a series circuit and describe how they relate.
5. I can show changes in voltage and current in a series circuit with a graph.
6. I can measure the equivalent resistance of a series circuit, and obtain the mathematical relationship.
7. I can calculate the voltage, current and resistance for various series circuits.
8. I can calculate the voltage, current and/or resistance for various parallel circuits.
9. I can predict the behaviors of various mixed series/parallel circuits and short circuits.
10. I can apply Ohm's Law verbally and mathematically.
11. I can relate voltage and current to power.
12. I can calculate the electrical power in watts, using the equation P=VI.
13. I can relate power to energy and time.
14. I can calculate the electrical energy in joules or kilowatt-hours for various circuits.
15. I can create a verbal, schematic, pictorial or mathematical description of a physical electrical circuit.
16. I can construct an electrical circuit from the verbal, schematic, mathematical, or pictorial representation of a circuit.

17. I can describe how electrical devices work.
18. I can use a multi-meter to measure current, voltage and resistance.
19. I can design and conduct a quantitative experiment to determine a mathematical relationship among current, voltage, and resistance (Ohm's Law).
20. I can identify the essential components of a wet-cell battery.
21. I can construct batteries using different combinations of electrodes and electrolytes.
22. I can conduct experiments to determine how the length, the diameter, and the resistivity of a wire affect its resistance and develop a formula.

Unit 3:

1. I can distinguish between position, change in position, and distance.
2. I can distinguish between an instant in time and a time interval.
3. I can describe the motion of an object, including the starting position, direction of motion, time elapsed, and velocity.
4. I can use technology (i.e., motion detector) to collect and analyze uniform motion data.
5. I can analyze and compare the motion of two objects.
6. I can verbally describe the motion of an object in uniform motion.
7. I can draw a motion diagram for an object in uniform motion.
8. I can draw and interpret an x vs. t graph and a v vs. t graph for an object's motion.
9. I can graphically determine the average velocity of an object from the slope of an x vs. t graph.
10. I can mathematically describe uniform motion as the slope of an x vs. t graph ($v = \Delta x/\Delta t$).
11. I can convert among verbal descriptions, motion diagrams, graphs and mathematical models.
12. I can use the formula to calculate speed, displacement or time interval of an object in uniform motion:
13. $v = \Delta x/\Delta t = (xf - xi)/(tf - ti)$
14. I can determine the displacement of an object by finding the area under the curve of a v vs. t

Unit 4:

1. I can compare and contrast x vs. t and v vs. t graphs for uniform accelerated motion with those for uniform motion.
2. I can compare and contrast the slopes of x vs. t and v vs. t graphs for uniform accelerated motion with those for uniform motion.
3. I can distinguish between instantaneous and average velocity.
4. I can determine the instantaneous velocity of the object at a given time.
5. I can determine the acceleration of the object from the slope of the v vs. t graph.
6. I can use technology (i.e., motion detectors) to measure accelerated motion and produce motion graphs.
7. I can compare motion for objects undergoing different accelerations.

8. I can design and conduct experiments to study uniform accelerated motion.
9. I can draw a motion diagram for an object in uniform accelerated motion.
10. I can mathematically describe acceleration as the slope of a v vs. t graph ($a = \Delta v/\Delta t$).
11. I can convert among verbal descriptions, motion diagrams, graphs and mathematical models.
12. I can construct the corresponding v vs. t graph from a given x vs. t graph, and vice versa.
13. I can construct the corresponding a vs. t graph from a given v vs. t graph, and vice versa
14. I can determine the instantaneous velocity of an accelerating object two ways:
    i. Determine the slope of the secant or tangent to an x vs. t graph at a given point.
    ii. Use the mathematical expression,
        1. $vf = vi + a\Delta t$.
15. I can determine the displacement of an accelerating object two ways:
    i. Find the area under a v vs. t graph.
    ii. Using the mathematical expression,
        1. $\Delta x = vi\Delta t + 1/2a(\Delta t)2$.
16. I can determine the acceleration of an accelerating object four ways:
    i. Find the slope of a v vs. t graph.
    ii. Use the mathematical expression,
        1. $a = \Delta v/\Delta t$.
    iii. Rearrange the mathematical expression,
        1. $\Delta x = vi\Delta t + 1/2a(\Delta t)2$.
    iv. Rearrange the mathematical expression,
        1. $vf = vi + a\Delta t$.

Unit 5:

1. I can identify different forces in a given physical situation.
2. I can measure the strength of a force using a spring scale.
3. I can identify the direction of a force.
4. I can distinguish between contact forces and field forces.
5. I can identify an agent, a receiver, an effect, and the direction of a force.
6. I can predict the outcome on a force by changing characteristics (e.g., roughness of a surface changes friction; size of an object changes air resistance).
7. I can use technology (i.e., force probes) to measure and analyze forces.
8. I can use data to construct a graph of force of gravity vs. mass.
9. I can determine the strength of the force of gravity from the slope of a force vs. mass graph.
10. I can develop a mathematical relationship between force of gravity (weight) and mass.
11. I can compare the strength of gravity on different planets and satellites of planets.

12. I can use data to construct a graph of elastic force vs. extension.
13. I can determine the strength of an elastic force from the slope of a force vs. extension graph.
14. I can develop a mathematical relationship between elastic force and extension of a stretchable object.
15. I can compare the strength of elastic force for different stretchable objects.
16. I can construct and label a force diagram for a given physical situation.
17. I can describe the effect of forces acting on an object.
18. I can draw a picture from a description of forces acting on an object.
19. I can determine the strength of force of gravity using the equation.
20. I can determine the strength of elastic force using the equation.
21. I can convert between verbal descriptions, force diagrams, graphs and mathematical models.
22. I can use the concept of balanced forces to calculate a specific force acting on a stationary object.
23. I can calculate the net force using Newton's Second Law.
24. I can identify that a force is required to start and to stop an object, to change velocity (speed and direction), but not to sustain motion (inertia).
25. I can determine situations where net force is zero.
26. I can relate the mass of an object to its inertia.
27. I can predict the relationship between action and reaction forces for interacting objects and then test the predictions, using technology (i.e., force probes).
28. I can identify the pairs of action and reaction forces for interacting objects.
29. I can construct a separate force diagram for each object in an interacting pair, and label the action and reaction forces.
30. I can draw the action-reaction pair of forces as equal in magnitude and in opposite direction (FAB = - FBA).
31. I can predict the relationship between force, mass, and acceleration.
32. I can show that force is related to acceleration (but not velocity).
33. I can demonstrate that a net force applied in (against) the direction of motion of an object will speed up (slow down) the object.
34. I can develop and use the mathematical relationship between force, mass, and acceleration, F = ma (Newton's Second Law).
35. I can identify the system for a given problem in which Newton's Second Law is applied.
36. I can show that the directions of net force and acceleration are the same.

Unit 6:

1. I can compare and contrast an inelastic and an elastic collision.
2. I can design an experiment to collect data for two objects in elastic and inelastic collisions.
3. I can investigate parameters that affect a collision.

4. I can use a simulation (or technology, such as motion detectors) to conduct an experiment and collect quantitative data on the mass and velocity of objects immediately before and after collisions.
5. I can identify a system in its initial and final states (before and after a collision).
6. I can calculate the linear momentum (p = mv) of an object.
7. I can calculate the initial and final linear momenta of the system.
8. I can compare the initial and final linear momenta of the system.
9. I can describe and apply the law of conservation of momentum.
10. I can manipulate the mass, velocity and direction of motion of colliding objects to see how momentum is conserved in collisions (from data or using a computer simulation).
11. I can describe in words the conservation of momentum for an inelastic collision.
12. I can draw a picture that indicates the system "before a collision" and "after a collision."
13. I can apply a mathematical model for the conservation of momentum between two colliding objects.
14. I can calculate the change in momentum for objects in a collision.
15. I can solve simple collision problems, using the principle of conservation of momentum.
16. I can describe the relationship between the force acting on an object in a collision and the change in momentum for that object, $F\Delta t = \Delta p$.
17. I can explain how impulse relates to momentum and force.

Unit 7:

1. I can differentiate between energy transfer, transformation and storage.
2. I can define open or closed physical systems for a given situation involving energy.
3. I can identify and compare different forms of energy storage: gravitational potential energy, elastic potential energy, kinetic energy, thermal energy.
4. I Identify the initial and final states of a physical system for a given energy transfer and/or transformation process.
5. I can recognize that energy is conserved in a closed system.
6. I can mathematically and graphically determine work, gravitational potential energy, elastic potential energy, kinetic energy, and power. (DOK3)
7. I can determine a mathematical expression for calculating work when the force and displacement of an object along the direction of the force is known.
8. I can determine the units used for measuring work and thus energy.
9. I can recognize that work is a physical quantity that can have both positive and negative values.
10. I can calculate work done by a force as the
    i. Product of that force and the displacement of the object along the direction of that force,

ii. Area under the force vs. displacement graph.

11. I can relate work and power to energy.
12. I can use the mathematical relationships for calculating energy with their corresponding units in problem-solving.
13. I can apply conservation of energy theorem in solving problems.
14. I can analyze a physical system in terms of energy storage, transfer and transformation using various representational tools (pictorial and/or verbal descriptions, pie charts, and bar graphs).
    i. I can distinguish between isolated and non-isolated systems.
    ii. I can operationally define an isolated system such that no energy transfers are occurring into or out of the system.
    iii. I can identify the forms of energy storage for a system in a given state.
    iv. I can use pie charts to represent the energy transfer and transformation when a system goes from one state to another.
    v. I can use bar graphs to represent the energy transfer and transformation when a system goes from one state to another.
    vi. I can relate energy transfers to external interactions.

15. I can relate the concept of work to an energy transfer mechanism.
16. I can demonstrate that a system has the potential to do work.
17. I can give examples of the three methods of energy transfer, e.g., working, heating and radiation.
18. I can relate work to the external net force applied on the system and its displacement.
19. I can relate work to the transfer of energy into or out of the system.
20. I can Design and conduct experiments to determine the energy stored in a system.
21. I can use technology (i.e., force probes) to measure and collect data to determine energy stored in a given system.
22. I can conduct an experiment to determine the relationship between gravitational potential energy and vertical height of an object with respect to a chosen reference frame.
23. I can relate the change in the gravitational potential energy of a system to the work done by the gravitational force.
24. I can conduct an experiment to determine the relationship between the elastic potential energy stored in a spring and its deformation.
25. I can relate the change in the elastic potential energy of a system to the work done by the elastic force.
26. I can conduct an experiment to determine the relationship between the kinetic energy stored in a moving object and the speed of the object.
27. I can conduct an experiment to determine the power output of a person.
28. I can relate the power to the rate of change of energy with time.

Unit 8:

1. I can explore and analyze pulses/waves by creating a pulse/wave and observing its motion in different media.
2. I can demonstrate how pulses/waves can be generated and how they transport energy without the transfer of matter.
3. I can compare and contrast longitudinal and transverse pulses/waves.
4. I can determine the parameters that affect the speed of a pulse/wave through a medium.
5. I can describe what happens to the characteristics of the incident pulse/wave (amplitude, shape, speed) when it reflects from a barrier (fixed or free end).
6. I can describe what happens to the characteristics of a pulse/wave (amplitude, shape, speed) when it travels from one medium to another (i.e., more dense to less dense, less dense to more dense).
7. I can determine what happens to the particles of the medium and to the characteristics of a pulse/wave when it meets another pulse/wave.
8. I can determine the amplitude of the resultant pulse/wave when two or more pulses/waves are superimposed.
9. I can use technology (i.e., computer simulations) to represent constructive and destructive interference.
10. I can determine the wavelength, nodes, and antinodes for a standing wave generated in a given media.
11. I can determine the factors that will influence the wavelength of the standing wave.
12. I can predict and conduct tests to determine which variables affect the speed of the wave: e.g., amplitude of the pulse, large pulse vs. short pulse, large linear density vs. small linear density, large tension vs. small tension.
13. I can represent wave phenomena diagrammatically (i.e., position of particles of the medium vs. position of wave).
14. I can draw pictorial representations of standing waves in fixed-end and free-end resonance tubes and strings.
15. I can use graphical and mathematical models to represent the relationship between the frequency of a disturbance and the wavelength of the resulting standing wave.
16. I can interpret the slope of a graph of wavelength vs. 1/frequency (λvs. T) for a given sound.
    i. Use the equation, $v = f\lambda$ in problem-solving.
17. I can describe sound in terms of wave characteristics.
18. I can determine the relationship between frequency and wavelength for sound waves.
19. I can investigate what factors might determine the speed of sound.
20. I can use the speed of sound in problem solving.
21. I can use technology (i.e., computer simulations) to represent the wave nature of sound.
22. I can relate the frequency of musical tones to pitch.

23. I can identify light as an electromagnetic wave.
24. I can compare and contrast light and mechanical waves.
25. I can compare and contrast light and sound.
26. I can illustrate and explain the behavior of different wavelengths of light.
27. I can predict the effect of different diffraction gratings on a beam of light.
28. I can identify the colors of white light.
29. I can label the regions of the electromagnetic spectrum.
30. I can explore the interaction between color filters and specific colors of light.
31. I can explain constructive and destructive interference of light.