Sparta Area School District
*Good people, great schools.*

# Course Outcome Summary

## Course Information: Physics 1 (SCAPPH)

**Description:** Students explore principles of Newtonian mechanics (including rotational motion); work, energy, and power; mechanical waves and sound; and introductory, simple circuits. The course is based on six Big Ideas, which encompass core scientific principles, theories, and processes that cut across traditional boundaries and provide a broad way of thinking about the physical world.

Students establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena. Focusing on these disciplinary practices enables teachers to use the principles of scientific inquiry to promote a more engaging and rigorous experience for students.

Twenty-five percent of instructional time is devoted to hands-on laboratory work with an emphasis on inquiry-based investigations. Investigations will require students to ask questions, make observations and predictions, design experiments, analyze data, and construct arguments in a collaborative setting, where they direct and monitor their progress.

**Instruction Level:** Grades 10-12

**Total Credits:** 2 credits

## Course Standards:

- Objects and systems have properties such as mass and charge. Systems may have internal structure
- Fields existing in space can be used to explain interactions
- The interactions of an object with other objects can be described by forces
- Interactions between systems can result in changes in those systems
- Changes that occur as a result of interactions are constrained by conservation laws
- Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena
- Use representations and models to communicate scientific phenomena and solve scientific problems
- Use mathematics to solve, apply, and estimate
- Engage in scientific questioning to extend thinking or to guide investigations within the context of the course
- Plan and implement data collection strategies in relation to a particular scientific question
- Perform data analysis and evaluation of evidence

- Work with scientific explanations and theories
- Connect, extrapolate, and relate knowledge across various scales, models, concepts, and representations

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| **Prerequisites:** | Students should have completed Geometry and be concurrently taking Algebra II or an equivalent course. |
| **Textbooks:** | Holt McDougal Physics: Student Edition 2012**,** 9780547586694 |

## Unit

1. **Kinematics in One Dimension**
2. **Kinematics in Two Dimensions**
3. **Newton’s First Law and Equilibrium**
4. **Newton’s Second Law and Acceleration**
5. **Two-Mass Systems and Newton’s Third Law**
6. **Work and the Conservation of Energy**
7. **Systems of Particles and Linear Momentum**
8. **Simple Harmonic Motion**
9. **Universal Gravitation and Orbits**
10. **Rotational Motion**
11. **Mechanical Waves and Sound**
12. **Electric Charge, Current, and Resistance**

## Unit Outlines

1. **Kinematics in One Dimension**
   **Standards:**
   - Use representations and models to communicate scientific phenomena and solve scientific problems
   - Perform data analysis and evaluation of evidence

   **Essential Questions**:
   - How are multiple representations (i.e., words, graphs, and equations) used to describe an object’s motion?
   - How do scalar measurements differ from vector measurements?
   - How are kinematics equations and graphs used to describe objects in free fall?

   **Students Can:**
   - The student is able to express the motion of an object using narrative, mathematical, and graphical representations.
   - The student is able to design an experimental investigation of the motion of an object.

- The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.
- The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.

2. **Kinematics in Two Dimensions**
   **Standards:**

- Engage in scientific questioning to extend thinking or to guide investigations within the context of the course
- Use representations and models to communicate scientific phenomena and solve scientific problems

**Essential Questions:**

- Why is knowledge of vectors and component calculation vital to understanding two-dimensional motion?
- How are the kinematics equations applied to objects experiencing motion in two dimensions?
- How do variables such as launch angle, velocity, and altitude affect the maximum height and range of a launched projectile?
- What do we mean when we say that the horizontal motion of a projectile is independent of its vertical motion?

**Students Can:**

- Express the motion of an object using narrative, mathematical, and graphical representations.
- Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations.
- Represent motion in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.
- Design an experimental investigation of the motion of an object

3. **Newton's First Law and Equilibrium**
   **Standards**:

- The interactions of an object with other objects can be described by forces
- Use representations and models to communicate scientific phenomena and solve scientific problems
- Changes that occur as a result of interactions are constrained by conservation laws

**Essential Questions**:

- What is Newton's first law and how does it explain static equilibrium?
- How is knowledge of the net force essential to understanding an object's constant velocity?
- How do free-body diagrams assist in problem solving for Newton's laws of motion?

**Students can:**

- Describe a force as an interaction between two objects and identify both objects for any force.
- Explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions.
- Challenge a claim that an object can exert a force on itself.
- Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.

4. **Newton's Second Law and Acceleration**

**Standards**:

- The interactions of an object with other objects can be described by forces
- Objects and systems have properties such as mass and charge. Systems may have internal structure
- Use representations and models to communicate scientific phenomena and solve scientific problems

**Essential Questions**:

- How does the presence of a net force determine the acceleration of an object?
- What is the nature of friction and how does it factor into an object's acceleration?

**Students Can:**

- Apply F m= g to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems.
- Design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration.
- Predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension.
- Re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object.

5. **Two-Mass Systems and Newton's Third Law**

**Standards**:

- Interactions between systems can result in changes in those systems
- The interactions of an object with other objects can be described by forces
- Use mathematics to solve, apply, and estimate

**Essential Questions:**

- What considerations must be made when a system is composed of two or more objects?
- Why is the Atwood machine an exemplar for systems of masses?
- What are action-reaction force pairs? And do they cancel each other?

**Students Can:**

- Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively.
- Make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.
- Model verbally or visually the properties of a system based on its substructure and to relate this to changes in the system properties over time as external variables are changed.
- Construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces.

6. **Work and the Conservation of Energy**

**Standards**:

- Changes that occur as a result of interactions are constrained by conservation laws

**Essential Questions**:

- How is the energy of a system defined?
- How is work represented graphically?
- What is mechanical energy and what factors affect its conservation?

**Students Can**:

- Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations.
- Make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy).
- Design an experiment and analyze data to examine how a force exerted on an object or system does work on the object or system as it moves through a distance.

7. **Systems of Particles and Linear Momentum**

**Standards**:

- Changes that occur as a result of interactions are constrained by conservation laws
- Work with scientific explanations and theories
- Connect, extrapolate, and relate knowledge across various scales, models, concepts, and representations

**Essential Questions:**

- What role does Newton's third law play in the conceptual and mathematical understanding of impulse and momentum?
- How is the impulse and momentum demonstrated by air bags in cars, thick-soled running shoes, and knee bending during a landing?
- How are collisions determined to be elastic or inelastic?

- How does a ballistic pendulum demonstrate both the conservation of energy and momentum?

**Students Can:**

- Analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted.
- Justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force.
- Qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic.
- Design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time.

8. **Simple Harmonic Motion**

**Standards:**
- The interactions of an object with other objects can be described by forces
- Perform data analysis and evaluation of evidence

**Essential Questions:**
- What is a simple harmonic oscillator?
- What factors affect the period of oscillation for a mass oscillating on a spring and for a simple pendulum?
- How does the back-and-forth motion of a box on a spring mirror the motion of a pendulum?

**Students Can:**
- Construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force.
- Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties.
- Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations.

9. **Universal Gravitation and Orbits**

**Standards:**
- Fields existing in space can be used to explain interactions
- The interactions of an object with other objects can be described by forces
- Connect, extrapolate, and relate knowledge across various scales, models, concepts, and representations

**Essential Questions:**

- How is the motion of a falling apple similar to the orbit of the moon?
- Why does a person's weight vary at various locations throughout the universe?
- How are the two equations used to calculate gravitational force similar and/or different?

**Students Can:**

- Use Newton's law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion.
- Apply g = G (M/r2) to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M.
- Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.
- Articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored

**10. Rotational Motion**

**Standards:**

- Objects and systems have properties such as mass and charge. Systems may have internal structure
- The interactions of an object with other objects can be described by forces
- Plan and implement data collection strategies in relation to a particular scientific question

**Essential Questions:**

- Can the kinematics equations be applied to rotating systems?
- How can Newton's law be applied to rotating systems?
- How does a net torque affect the angular momentum of a rotating system?

**Students Can:**

- Design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.
- Estimate the torque on an object caused by various forces in comparison to other situations.
- Calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction).

**11. Mechanical Waves and Sound**

**Standards:**

- Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena
- Use representations and models to communicate scientific phenomena and solve scientific problems

**Essential Questions:**

- How are velocity, frequency, and wavelength used to describe a wave?
- What factors affect how a wave is reflected?
- How is it possible for two waves to occupy the same space at the same time?
- What conditions are necessary to form a standing wave?

**Students Can:**

- Use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave.
- Design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples.
- Use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats.

**12. Electric Charge, Current, and Resistance**

**Standards:**

- Objects and systems have properties such as mass and charge. Systems may have internal structure
- The interactions of an object with other objects can be described by forces

**Essential Questions:**

- What is the cause of static electricity?
- How are electric forces similar to gravitational forces?
- How does an electric circuit demonstrate conservation of charge?
- What factors affect the resistance of a wire?

**Students Can:**

- Make claims about natural phenomena based on conservation of electric charge.
- Make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.
- Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.

- Use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit.