PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Physics

Curriculum Writing Committee:

Robert E. Curtis Jr. PE

Grade Level: 11th & 12th

Date of Board Approval: June 2026

Course Weighting: Physics

Major Assessments	**45%**
Skills Application	**30%**
Skills Practice	**20%**
Participation	**5%**

Curriculum Map

Overview:

Physics is the most fundamental science and studies matter, energy, and interactions between systems, seeking to understand the basic principles that govern interactions between objects on Earth and in the entire universe. It investigates everything from the smallest subatomic particles to the largest cosmic structures, exploring ideas like motion, force, and space and time.

- Matter and energy: Physics examines all physical material (matter) and its ability to do work (energy).
- Fundamental forces: It is concerned with the forces that cause interactions between matter, such as gravity and electromagnetism.
- Interdisciplinary nature: It serves as a foundation for many other disciplines, including astronomy, chemistry, biology, and engineering.
- Applications: The principles of physics are applied in countless everyday activities and technologies, such as driving a car, using a phone, and medical imaging.

The major focus of the Physics course is to provide a conceptual understanding of the major topics in physics, including Newton's Laws, Momentum, Energy, Rotational Motion, Thermodynamics, Electricity, Magnetism, and Nuclear Physics. The topics are chosen to address all relevant state standards, as well as assorted topics covered in Advanced Placement Physics.

Physics is a high school level course appropriate for 11th or 12th grade students interested in understanding the principles of how our world works. Other than their concurrent or previous enrollment in college preparatory mathematics and science courses, this course assumes no previous knowledge.

Goals:

- **Marking Period 1 (45 days) -** Students will be able to understand and apply the principles of Newton's Laws as discussed in the following Chapters in the course textbook:
    - **Newton's Laws (Unit 1)**
        - Chapter 01: About Science (6 days)
        - Chapter 02: Mechanical Equilibrium (6 days)
        - Chapter 03: Newton's First Law of Motion – Inertia (7 days)
        - Chapter 04: Linear Motion (6 days)
        - Chapter 05: Projectile Motion (6 days)
        - Chapter 06: Newton's Second Law of Motion – Force and Acceleration (7 days)
        - Chapter 07: Newton's Third Law of Motion – Action and Reaction (7 days)
- **Marking Period Two: (45 days) -** Students will be able to understand and apply the principles of Momentum, Energy, and Rotational Motion as discussed in the following Chapters in the course textbook:
    - **Momentum, Energy, and Rotational Motion (Unit 2)**
        - Chapter 08: Momentum (6 days)
        - Chapter 09: Energy (7 days)
        - Chapter 10: Circular Motion (6 days)
        - Chapter 11: Rotational Equilibrium (6 days)
        - Chapter 12: Rotational Motion (6 days)
        - Chapter 13: Universal Gravitation (7 days)
        - Chapter 14: Satellite Motion (7 days)
- **Marking Period Three: (45 days) -** Students will be able to understand and apply the principles of Thermodynamics and Electricity as discussed in the following Chapters in the course textbook:
    - **Thermodynamics and Electricity (Unit 3)**
        - Chapter 21: Temperature, Heat, and Expansion (6 days)
        - Chapter 22: Heat Transfer (6 days)
        - Chapter 24: Thermodynamics (6 days)
        - Chapter 25: Vibrations and Waves (6 days)
        - Chapter 32: Electrostatics (7 days)
        - Chapter 33: Electric Fields and Potential (7 days)
        - Chapter 34: Electric Current (7 days)
- **Marking Period Four: (45 days) - St**udents will be able to understand and apply the principles of Magnetism and Nuclear Physics as discussed in the following Chapters in the course textbook:
    - **Magnetism and Nuclear Physics (Unit 4)**
        - Chapter 35: Electric Circuits (7 days)
        - Chapter 36: Magnetism (7 days)
        - Chapter 37: Electromagnetic Induction (7 days)
        - Chapter 38: The Atom and the Quantum (8 days)
        - Chapter 39: The Atomic Nucleus and Radioactivity (8 days)

- Chapter 40: Nuclear Fission and Fusion (8 days)

Big Ideas:

- All forms of matter exist as a result of the combination or rearrangement of atoms.
- Phenomena involving nuclei explain the formation of the elements, radioactivity, and the release of energy.
- A change in motion of interacting objects can be explained and predicted by forces.
- All forces between objects, regardless of size or direction, arise from only a few types of interactions.
- Energy can be modeled as either motions of particles or as being stored in force fields.
- The total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Forces between objects can result in transfer of energy between these objects.
- Waves are repeating patterns of motion that transfer energy and information without transferring matter.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave pattern of changing electric and magnetic fields that interact with matter.
- Useful modern technologies and instruments have been designed based on an understanding of waves and their interactions with matter.

Textbook and Supplemental Resources:

- **Primary Textbook Name:** Hewitt, Paul G. Hewitt *Conceptual Physics.* Boston, MA.
  - Textbook ISBN: 978-0-13-364749-5
  - Textbook Publisher/Year of Publication: Pearson, 2009.
- **Supplemental Resources:**
  - Concept Development Practice Pages, Chapter Exercises, Next-Time Questions, Laboratory Investigations, Additional Practice Pages – supplemental resources for *Conceptual Physics*.

Curriculum Plan

Unit 1: Newton's Laws (45 Days)

Chapter 01: About Science (6 Days)

- **Standard:**
    - CC.3.5.11-12.A. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
    - CC.3.5.11-12.B. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
    - CC.3.5.11-12.C. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
    - CC.3.5.11-12.D. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
    - CC.3.5.11-12.E. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
    - CC.3.5.11-12.F. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
    - CC.3.5.11-12.G. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
    - CC.3.5.11-12.H. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
    - CC.3.5.11-12.I. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
    - CC.3.5.11-12.J. By the end of grade 12, read and comprehend science/technical texts in the grades 11–12 text complexity band independently and proficiently.
    - CC.3.6.11-12.A. Write arguments focused on discipline-specific content.
        - Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
        - Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.

        - Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
        - Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
        - Provide a concluding statement or section that follows from or supports the argument presented.
    - CC.3.6.11-12.B. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
        - Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
        - Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
        - Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
        - Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.
        - Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
    - CC.3.6.11-12.C. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
    - CC.3.6.11-12.D. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
    - CC.3.6.11-12.E. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
    - CC.3.6.11-12.F. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation
    - CC.3.6.11-12.G. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

    - CC.3.6.11-12.H. Draw evidence from informational texts to support analysis, reflection, and research.
    - CC.3.6.11-12.I. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

- **Anchoring Phenomena:**
    - Scientific thinking can be used to make sense of advertising claims and help to separate fact from fiction when deciding whether to purchase a product for its claimed benefits. The website https://www.usatoday.com/story/money/2020/12/16/39-most-outrageous-product-claims-of-all-time/115127274/ is an example of some outrageous advertising claims.

Objectives:

- Explain what physics is about. (DOK 3)
- Explain why mathematics is the language of science. (DOK 3)
- Outline scientific methods. (DOK 2)
- Describe circumstances under which a hypothesis, law, or principle must be changed or abandoned. (DOK 1)
- Determine whether a hypothesis is scientific. (DOK 2)
- Distinguish between science and technology. (DOK 2)
- Distinguish among science, art, and religion. (DOK 2)
- Describe how progress today differs from progress thousands of years ago. (DOK 1)

Core Activities and Corresponding Instructional Methods:

- "Do Sneakers Make You Faster?" Introductory Activity
- Independent Reading of Chapter 1: About Science in the textbook.
- Chapter 1 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 1 with student skeleton note page
- Chapter 1 Concept Development Practice Pages.
- "Linearizing Data" Lab.

Correspondent Vocabulary:

- Scientific method, law, fact, principle, hypothesis, scientific theory.

Assessments:

- **Diagnostic:**
    - Student performance on Introductory Activity and Exercises.
- **Formative:**
    - Student performance on Concept Development Practice Pages and Lab.
- **Summative:**
    - Chapter 1 Test
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.

- **Extensions:**
    - Additional Think & Explain questions from the textbook.
    - Appendix C Graphing Exercises from the textbook.

Chapter 02: Mechanical Equilibrium (6 Days)

- **Standard:** 3.2.9-12.I: 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.
    - **Clarifying Statement:**
        - Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.
    - **Assessment Boundary:**
        - Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Analyzing and Interpreting Data ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Forces and Motion	● Cause and Effect

- **Anchoring Phenomena:**
    - Why does a backpack hang motionless from two angled ropes? This will require students to investigate net force, the equilibrium rule, vector components, support force and tension, and resultant forces.

Objectives:

- Distinguish between force and net force. (DOK 2)
- Describe the equilibrium rule and give examples. (DOK 2)
- Distinguish between support force and weight. (DOK 2)
- Give examples of moving objects that are in equilibrium. (DOK 2)
- Determine the resultant of a pair of parallel or non-parallel vectors. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "How Do You Know When an Object Is in Equilibrium?" Introductory Activity
- Independent Reading of Chapter 2: Mechanical Equilibrium in the textbook.
- Chapter 2 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 2 with student skeleton note page
- Chapter 2 Concept Development Practice Pages.
- "Walking the Plank" Lab.

Correspondent Vocabulary:

- Force, net force, vector, vector quantity, scalar quantity, mechanical equilibrium, equilibrium rule, support force, resultant.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Walking the Plank"
  - Model: "Why does a backpack hang motionless from two angled ropes?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 03: Newton's First Law of Motion - Inertia (7 Days)

- **Standard:** 3.2.9-12.I: 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.
  - **Clarifying Statement:**
    - Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.
  - **Assessment Boundary:**
    - Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Analyzing and Interpreting Data ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Forces and Motion	● Cause and Effect

- **Anchoring Phenomena:**
    - "Why Do You Lurch Forward When a Car Stops Suddenly?" A car brakes quickly and passengers jerk forward even though the car is stopping. Driving Questions include: Why does your body keep moving when the car stops? Why do seatbelts matter in sudden stops? This will require students to investigate inertia and balanced vs. unbalanced forces.

Objectives:
- Describe Aristotle's concept of motion. (DOK 1)
- Describe Copernicus's idea about Earth's motion. (DOK 1)
- Describe Galileo's idea about when a force is needed to keep an object moving. (DOK 1)
- State Newton's first law of motion. (DOK 1)
- Describe the relationship between mass and inertia. (DOK 1)
- Explain how the law of inertia applies to objects in motion. (DOK 2)

Core Activities and Corresponding Instructional Methods:
- "Can You Snap a Card Out From Under a Coin?" Introductory Activity
- Independent Reading of Chapter 3: Newton's First Law of Motion - Inertia in the textbook.
- Chapter 3 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 3 with student skeleton note page
- Chapter 3 Concept Development Practice Pages.
- "Buckle Up" Lab.

Correspondent Vocabulary:
- Friction, inertia, Newton's First Law, Law of Inertia, kilograms, mass, weight, Newton.

Assessments:
- **Diagnostic:**
    - Introduction of the phenomenon and Driving Question Board.
    - Student performance on Introductory Activity and Exercises.
    - Teacher questioning and observation.
    - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
    - Student performance on Concept Development Practice Pages.

    - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
    - Teacher questioning and observation.
    - Define vocabulary words for this unit.
- **Summative:**
    - Common Assessment Chapter Test
    - Laboratory Investigation: "Buckle Up"
    - Model: "Why Do You Lurch Forward When a Car Stops Suddenly?"
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.

Chapter 04: Linear Motion (6 Days)

- **Standard:** 3.2.9-12.I: 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.
    - **Clarifying Statement:**
        - Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.
    - **Assessment Boundary:**
        - Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Analyzing and Interpreting Data ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Forces and Motion	● Cause and Effect

- **Anchoring Phenomena:**
    - "Who Was Actually Faster?" Two students run a 100-meter dash. One starts fast and slows down. The other starts slow and speeds up. They finish at nearly the same time. Driving Questions include: Who was faster? Is finishing first the same as having the greatest speed? How can we represent their motion to compare it? This will require students to investigate Position vs. time graphs, Velocity vs. time graphs, Average vs. instantaneous speed, and Acceleration.

Objectives:

- Explain how you can tell an object is moving. (DOK 2)
- Describe how you can calculate speed. (DOK 1)

- Distinguish between speed and velocity. (DOK 2)
- Describe how you can calculate acceleration. (DOK 1)
- Describe the acceleration of an object in free fall. (DOK 1)
- Describe how the distance fallen per second changes for an object in free fall. (DOK 2)
- Describe what the slope of a speed-versus-time graph represents. (DOK 2)
- Describe how air resistance affects the motion of falling objects. (DOK 2)
- Explain the relationship between velocity and acceleration. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "Do Objects Fall Faster the Longer They Fall?" Introductory Activity
- Independent Reading of Chapter 4: Linear Motion in the textbook.
- Chapter 4 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 4 with student skeleton note page
- Chapter 4 Concept Development Practice Pages.
- "Merrily We Roll Along!" Lab.

Correspondent Vocabulary:

- Relative, speed, instantaneous speed, average speed, velocity, acceleration, free fall, elapsed time.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Merrily We Roll Along!"
  - Model: "Who Was Actually Faster?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 05: Projectile Motion (6 Days)

- **Standard:** 3.2.9-12.I: 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.
    - **Clarifying Statement:**
        - Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.
    - **Assessment Boundary:**
        - Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Analyzing and Interpreting Data ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Forces and Motion	● Cause and Effect

- **Anchoring Phenomena:**
    - "Why Do Basketball Players Aim High?" A basketball follows a curved path into the hoop. Driving Questions include: Why is the path curved instead of straight? Why doesn't the ball move forward faster as it falls? What determines how far it travels? This will require students to investigate Parabolic trajectories, Launch angle, Initial velocity components, and Range.

Objectives:

- Distinguish between a vector quantity and a scalar quantity. (DOK 2)
- Explain how to find the resultant of two perpendicular vectors. (DOK 2)
- Describe how the components of a vector affect each other. (DOK 2)
- Describe the components of projectile motion. (DOK 1)
- Describe the downward motion of a horizontally launched projectile. (DOK 2)
- Describe how the distance fallen per second changes for an object in free fall. (DOK 2)
- Describe how far below an imaginary straight-line path a projectile falls. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "How Should You Aim to Hit a Falling Target?" Introductory Activity
- Independent Reading of Chapter 5: Projectile Motion in the textbook.
- Chapter 5 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 5 with student skeleton note page
- Chapter 5 Concept Development Practice Pages.
- "Bull's Eye" Lab.

Correspondent Vocabulary:

- Components, resolution, projectile.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Bull's Eye"
  - Model: "Why Do Basketball Players Aim High?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 06: Newton's Second Law of Motion - Force and Acceleration (7 Days)

- **Standard:** 3.2.9-12.I: 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.
  - **Clarifying Statement:**
    - Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.
  - **Assessment Boundary:**
    - Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Analyzing and Interpreting Data ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Forces and Motion	● Cause and Effect

- **Anchoring Phenomena:**
    - "The "Empty Cart vs. Loaded Cart" Mystery" Two identical carts are pushed with the same force. One is empty. The other is loaded with additional mass. The empty cart accelerates much more. Driving Questions include: Why doesn't the heavier cart speed up as much? If we push harder, what changes? What exactly determines acceleration? This will require students to investigate force, mass, acceleration, and the proportional relationship in Newton's Second Law of Motion.

Objectives:

- State the relationship between acceleration and net force. (DOK 1)
- State the relationship between acceleration and mass. (DOK 1)
- State and explain Newton's second law of motion. (DOK 2)
- List the factors that affect the force of friction between surfaces. (DOK 1)
- Distinguish between force and pressure. (DOK 2)
- Explain why the acceleration of an object in free fall does not depend upon the mass of the object. (DOK 3)
- List the factors that affect the air resistance force on an object. (DOK 1)

Core Activities and Corresponding Instructional Methods:

- "What Effect Does Air Resistance Have on Falling Objects?" Introductory Activity
- Independent Reading of Chapter 6: Newton's Second Law of Motion - Force and Acceleration in the textbook.
- Chapter 6 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 6 with student skeleton note page
- Chapter 6 Concept Development Practice Pages.
- "Constant Force and Changing Mass" and "Constant Mass and Changing Force" Labs.

Correspondent Vocabulary:

- Inversely, Newton's second law, fluid, air resistance, free-body diagram, pressure, Pascal, terminal speed, terminal velocity.

Assessments:

- **Diagnostic:**
    - Introduction of the phenomenon and Driving Question Board.
    - Student performance on Introductory Activity and Exercises.
    - Teacher questioning and observation.
    - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
    - Student performance on Concept Development Practice Pages.
    - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
    - Teacher questioning and observation.
    - Define vocabulary words for this unit.
- **Summative:**
    - Common Assessment Chapter Test
    - Laboratory Investigations: "Constant Force and Changing Mass" and "Constant Mass and Changing Force"

    - Model: "The "Empty Cart vs. Loaded Cart" Mystery?"
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.

Chapter 07: Newton's Third Law of Motion - Action and Reaction (7 Days)

- **Standard:** 3.2.10.B1: Use Newton's Third Law to explain forces as interactions between bodies.

- **Anchoring Phenomena:**
    - "Balloon Rocket on a String" A balloon taped to a straw shoots forward when air rushes out the back. Driving Questions include: What pushes the balloon forward? Is the air pushing the balloon, or is the balloon pushing the air? Why does releasing more air make it go faster? This will require students to investigate force pairs and opposite-direction forces as well as perform interaction-based thinking.

Objectives:

- Define force as part of an interaction. (DOK 1)
- State Newton's third law of motion. (DOK 1)
- Describe how to identify a pair of action–reaction forces. (DOK 2)
- Explain why the accelerations caused by an action force and by a reaction force do not have to be equal. (DOK 3)
- Explain why an action force is not cancelled by the reaction force. (DOK 3)
- Explain how a horse-cart system accelerates. (DOK 3)
- Explain what must occur in every interaction between things. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "Can There Be Only One Force In an Interaction?" Introductory Activity
- Independent Reading of Chapter 7: Newton's Third Law of Motion - Action and Reaction in the textbook.
- Chapter 7 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 7 with student skeleton note page
- Chapter 7 Concept Development Practice Pages.
- "Tension" Lab.

Correspondent Vocabulary:

- Interaction, Newton's Third Law, action force, reaction force.

Assessments:

- **Diagnostic:**
    - Introduction of the phenomenon and Driving Question Board.
    - Student performance on Introductory Activity and Exercises.
    - Teacher questioning and observation.

    - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
    - Student performance on Concept Development Practice Pages.
    - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
    - Teacher questioning and observation.
    - Define vocabulary words for this unit.
- **Summative:**
    - Common Assessment Chapter Test
    - Laboratory Investigation: "Tension"
    - Model: "Balloon Rocket on a String"
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.
    - MP1 Culminating Project: Soda Bottle Rockets
        - Example of this project is at https://www.instructables.com/Soda-Bottle-Rockets/.

Unit 2: Momentum, Energy, and Rotational Motion (45 Days)

Chapter 08: Momentum (6 Days)

- **Standard:** 3.2.9-12.J: 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.
    - **Clarifying Statement:**
        - Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.
    - **Assessment Boundary:**
        - Assessment is limited to systems of two macroscopic bodies moving in one dimension.
- **Standard:** 3.2.9-12.K: Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.
    - **Clarifying Statement:**
        - Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.
    - **Assessment Boundary:**
        - Assessment is limited to qualitative evaluations and/or algebraic manipulations.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Using Mathematics and Computational Thinking ● Constructing Explanations and Designing Solutions	● Forces and Motion ● Defining and Delimiting an Engineering Problem ● Optimizing the Design Solution	● Systems and System Models ● Cause and Effect

- **Anchoring Phenomena:**
    - "Why Do Airbags Save Lives?" In a car crash, two identical cars collide at the same speed. In one car, the driver walks away with minor injuries because of airbags. In the other (no airbags), the driver is seriously injured — even though the crash speed was the same. Driving Questions include: If both drivers had the same mass and were moving at the same speed, why were the outcomes so different? Why doesn't the airbag reduce your momentum? What exactly is it reducing? Would a heavier person experience a different force? What would happen if the airbag inflated too slowly? This will require students to investigate momentum (Why larger mass or speed increases crash severity), Impulse-Momentum Theorem, Force vs. Time (Airbags increase the time over which momentum changes → reduces force), Newton's Third Law (The car hits you just as hard as you hit the car), and Conservation of Momentum (Can extend into two-car collision scenarios).

Objectives:

- Define momentum. (DOK 1)
- Define impulse and describe how it affects changes in momentum. (DOK 2)
- Explain why an impulse is greater when an object bounces than when the same object comes to a sudden stop. (DOK 3)
- State the law of conservation of momentum. (DOK 1)
- Describe how the conservation of momentum applies to collisions. (DOK 2)
- Describe how the vector nature of momentum affects the law of conservation of momentum. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "How Does a Collision Affect the Motion of Marbles?" Introductory Activity
- Independent Reading of Chapter 8: Momentum in the textbook.
- Chapter 8 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 8 with student skeleton note page
- Chapter 8 Concept Development Practice Pages.
- "Conservation of Momentum" Lab.

Correspondent Vocabulary:

- Momentum, impulse, law of conservation of momentum, elastic collision, inelastic collision.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Conservation of Momentum"
  - Model: "Why Do Airbags Save Lives?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 09: Energy (7 Days)

- **Standard:** 3.2.9-12.O: 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.
  - **Clarifying Statement:**
    - Emphasis is on explaining the meaning of mathematical expressions used in the model.
  - **Assessment Boundary:**
    - Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.
- **Standard:** 3.2.9-12.P: 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).
  - **Clarifying Statement:**
    - Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations
  - **Assessment Boundary:**

        - N/A
- **Standard:** 3.2.9-12.Q: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
    - **Clarifying Statement:**
        - Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency
    - **Assessment Boundary:**
        - Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Using Mathematics and Computational Thinking ● Developing and Using Models ● Constructing Explanations and Designing Solutions	● Definitions of Energy ● Conservation of Energy and Energy Transfer ● Energy in Chemical Processes ● Defining and Delimiting an Engineering Problem	● Systems and System Models ● Scientific Knowledge Assumes an Order and Consistency in Natural Systems ● Energy and Matter ● Influence of Engineering, Technology, and Science on Society and the Natural World

- **Anchoring Phenomena:**
    - "A Roller Coaster Without an Engine" A roller coaster ride that uses the interchange between gravitational potential energy and kinetic energy to provide a thrilling ride with climbs, loops, hills, and turns. Driving Questions include: How can a roller coaster travel through the entire track without an engine pushing it the whole time? This will require students to investigate the connections between many concepts in this unit (Gravitational potential energy, Kinetic energy, Energy transformations, Conservation of energy, Energy transfer (friction, sound, heat), and Efficiency and energy losses).

Objectives:

- Define and describe work. (DOK 1)
- Define and describe power. (DOK 1)
- State the two forms of mechanical energy. (DOK 1)
- State three forms of potential energy. (DOK 1)
- Describe how work and kinetic energy are related. (DOK 2)
- State the work-energy theorem. (DOK 1)
- State the law of conservation of energy. (DOK 1)
- Describe how a machine uses energy. (DOK 2)

- Explain why no machine can be 100% efficient. (DOK 3)
- Describe the role of energy in living organisms. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "Where Does a Popper Toy Get Its Energy?" Introductory Activity
- Independent Reading of Chapter 9: Energy in the textbook.
- Chapter 9 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 9 with student skeleton note page
- Chapter 9 Concept Development Practice Pages.
- "Conserving Your Energy" Lab.

Correspondent Vocabulary:

- Work, joule, power, watt, energy, mechanical energy, potential energy, kinetic energy, work-energy theorem, law of conservation of energy, machine, lever, fulcrum, mechanical advantage, pulley, efficiency, fuel cell.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Conserving Your Energy"
  - Model: "A Roller Coaster Without an Engine"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 10: Circular Motion (6 Days)

- **Standard:** 3.2.9-12.J: 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.
  - **Clarifying Statement:**
    - Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.

- **Assessment Boundary:**
  - Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Analyzing and Interpreting Data ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Forces and Motion	● Cause and Effect

- **Anchoring Phenomena:**
  - "Clothes in a Washing Machine Spin Cycle" The actual phenomenon is that during the spin cycle, water is forced out of clothes through holes in the drum. Driving Questions include: Why does spinning remove water from clothes? This will require students to investigate the connections between many concepts in this unit (Inertia, Circular motion and apparent "centrifugal" effect, and Radial force).

Objectives:
- Describe the two types of circular motion. (DOK 1)
- Describe the relationship among tangential speed, rotational speed, and radial distance. (DOK 2)
- Describe the factors that affect the centripetal force acting on an object. (DOK 2)
- Explain the "centrifugal-force effect." (DOK 2)
- Explain why centrifugal force is not considered a true force. (DOK 3)

Core Activities and Corresponding Instructional Methods:
- "Why Do Objects Move in Circles?" Introductory Activity
- Independent Reading of Chapter 10: Circular Motion in the textbook.
- Chapter 10 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 10 with student skeleton note page.
- Chapter 10 Concept Development Practice Pages.
- "The Flying Pig" Lab.

Correspondent Vocabulary:
- Axis, rotation, revolution, linear speed, tangential speed, rotational speed, centripetal force, centrifugal force.

Assessments:
- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.

    - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
    - Student performance on Concept Development Practice Pages.
    - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
    - Teacher questioning and observation.
    - Define vocabulary words for this unit.
- **Summative:**
    - Common Assessment Chapter Test
    - Laboratory Investigation: "The Flying Pig"
    - Model: "Clothes in a Washing Machine Spin Cycle"
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.

Chapter 11: Rotational Equilibrium (6 Days)

- **Standard:** 3.2.P.B1: Relate torque and rotational inertia to explain rotational motion.

Anchoring Phenomena:

- "A Construction Crane Lifting Heavy Loads" A crane can lift extremely heavy loads without tipping because of counterweights. Driving Questions include: Why doesn't the crane tip forward when lifting something heavy? This will require students to investigate the connections between many concepts in this unit (Counterweights, Torque balance, Center of mass, Rotational equilibrium in engineering).

Objectives:

- Describe how to make an object turn or rotate. (DOK 1)
- Explain what happens when balanced torques act on an object. (DOK 2)
- Describe how to find an object's center of mass. (DOK 2)
- Describe how the center of gravity of an everyday object is related to its center of mass. (DOK 2)
- Describe how to predict whether an object will topple. (DOK 3)
- Explain why the center of gravity of a person is not located in a fixed place. (DOK 3)
- Describe what happens to the center of gravity of an object when the object is toppled. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "How Far Can Objects Be Tipped Before They Topple Over?" Introductory Activity
- Independent Reading of Chapter 11: Rotational Equilibrium in the textbook.
- Chapter 11 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 11 with student skeleton note page.
- Chapter 11 Concept Development Practice Pages.
- "Keeping in Balance" Lab.

Correspondent Vocabulary:

- Torque, lever arm, center of mass, center of gravity, unstable equilibrium, stable equilibrium, neutral equilibrium.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Keeping in Balance"
  - Model: "A Construction Crane Lifting Heavy Loads"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 12: Rotational Motion (6 Days)

- **Standard:** 3.2.P.B1: Relate torque and rotational inertia to explain rotational motion.
- **Anchoring Phenomena:**
  - "Why Do Figure Skaters Spin Faster When They Pull in Their Arms?" Figure skating athletes often perform spins where they begin rotating slowly with their arms extended, then suddenly pull their arms inward and spin dramatically faster. Driving Questions include: Why does a spinning person rotate faster when they pull their arms closer to their body? Why does body position affect spinning speed? Is this related to mass or weight? Does friction with the ice matter? Would the same thing happen in space? Why do divers tuck during flips? This will require students to investigate Rotational inertia, angular velocity, torque, and Conservation of angular momentum.

Objectives:

- Describe how the rotational inertia of an object affects how easily the rotational speed of the object changes. (DOK 2)
- List the three principal axes of rotation in the human body. (DOK 1)
- Describe what happens when objects of the same shape but different sizes are rolled down an incline. (DOK 2)

- Explain how Newton's first law applies to rotating systems. (DOK 3)
- Describe what happens to angular momentum when no net external torque acts on an object. (DOK 2)
- Explain how gravity can be simulated. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "What Makes an Object Easy to Rotate?" Introductory Activity
- Independent Reading of Chapter 12: Rotational Motion in the textbook.
- Chapter 12 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 12 with student skeleton note page
- Chapter 12 Concept Development Practice Pages.
- "Rotational Derby" Lab.

Correspondent Vocabulary:

- Rotational inertia, linear momentum, angular momentum, rotational velocity, law of conservation of angular momentum.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Rotational Derby"
  - Model: "What Makes an Object Easy to Rotate?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 13: Universal Gravitation (7 Days)

- **Standard:** 3.2.9-12.L: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
    - **Clarifying Statement:**
        - Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields..
    - **Assessment Boundary:**
        - Assessment is limited to systems with two objects.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Using Mathematics and Computational Thinking ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Types of Interactions	● Patterns

- **Anchoring Phenomena:**
    - "Why Doesn't the Moon Fall to Earth?" The Moon orbits around Earth once about every 27 days. We know Earth's gravity pulls objects toward it—so a natural question arises: If gravity pulls everything down, why doesn't the Moon crash into Earth? Driving Questions include: How can gravity pull the Moon toward Earth while the Moon continues to orbit instead of falling? Is the Moon falling but missing Earth? What keeps it moving sideways? Does the Moon have its own gravity? Would astronauts fall toward Earth from the Moon? How strong is gravity in space? This will require students to investigate Universal gravitation, Orbital motion, Inverse-square relationship of gravity, Mass and gravitational attraction, Gravity and acceleration, and how satellites orbit planets.

Objectives:

- Explain Newton's reasoning about the apple falling from the tree. (DOK 2)
- Explain why the Moon doesn't hit Earth. (DOK 2)
- Explain how Newton's theory of gravity confirmed the Copernican theory of the solar system. (DOK 3)
- Describe what Newton discovered about gravity. (DOK 1)
- Describe how the force of gravity changes with distance. (DOK 2)
- Describe the gravitational field that surrounds Earth. (DOK 2)
- Describe the gravitational field at Earth's center. (DOK 2)
- Describe the sensation we interpret as weight. (DOK 2)
- Explain ocean tides. (DOK 3)
- Describe the gravitational field around a black hole. (DOK 2)
- Explain the importance of the formulation of the law of universal gravitation. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "How Does the Surface Area of a Balloon Vary With Diameter?" Introductory Activity
- Independent Reading of Chapter 13: Universal Gravitation in the textbook.
- Chapter 13 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 13 with student skeleton note page
- Chapter 13 Concept Development Practice Pages.
- "Apparent Weightlessness" Lab.

Correspondent Vocabulary:

- Law of universal gravitation, universal gravitational constant, inverse-square law, gravitational field, weightlessness, spring tide, neap tide, black hole, perturbation.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Apparent Weightlessness"
  - Model: "Why Doesn't the Moon Fall to Earth?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 14: Satellite Motion (7 Days)

- **Standard:** 3.2.9-12.L: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
  - **Clarifying Statement:**
    - Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields..
  - **Assessment Boundary:**
    - Assessment is limited to systems with two objects.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Using Mathematics and Computational Thinking ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Types of Interactions	● Patterns

- **Anchoring Phenomena:**
    - "Why Do Astronauts Float Inside the International Space Station?" Astronauts appear weightless, drifting freely inside the International Space Station. Objects float alongside them. Driving Questions include: If gravity is still acting on the ISS, why do astronauts experience "weightlessness"? This will require students to investigate free fall, gravity in orbit, sensation of weight vs gravitational force, and orbital motion.

Objectives:

- Explain how the speed of a satellite in circular orbit around Earth is related to the distance an object falls in the first second due to gravity. (DOK 3)
- Describe the motion of a satellite in a circular orbit. (DOK 2)
- Describe the shape of the path of a satellite in an orbit around Earth. (DOK 1)
- Apply the energy conservation law to describe changes in the PE and KE of a satellite in different portions of an elliptical orbit. (DOK 3)
- State Kepler's three laws of planetary motion. (DOK 1)
- Determine the vertical speed required to ensure a projectile can "escape" Earth. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "What Happens When You Disturb the Path of a Pendulum?" Introductory Activity
- Independent Reading of Chapter 14: Satellite Motion in the textbook.
- Chapter 14 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 14 with student skeleton note page
- Chapter 14 Concept Development Practice Pages.
- "Tracking Mars" Lab.

Correspondent Vocabulary:

- Satellite, period, ellipse, focus, apogee, perigee, Kepler's laws of planetary motion, escape speed.

Assessments:

- **Diagnostic:**
    - Introduction of the phenomenon and Driving Question Board.
    - Student performance on Introductory Activity and Exercises.
    - Teacher questioning and observation.

    - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
    - Student performance on Concept Development Practice Pages.
    - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
    - Teacher questioning and observation.
    - Define vocabulary words for this unit.
- **Summative:**
    - Common Assessment Chapter Test
    - Laboratory Investigation: "Tracking Mars"
    - Model: "What Happens When You Disturb the Path of a Pendulum?"
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.
    - MP2 Culminating Project: Egg Drop Project
        - Example of this project is at https://www.scienceworld.ca/resource/egg-drop/.

Unit 3: Thermodynamics and Electricity (45 Days)

Chapter 21: Temperature, Heat, and Expansion (6 Days)

- **Standard:** 3.2.P.B3: Analyze the factors that influence convection, conduction, and radiation between objects or regions that are at different temperatures.
- **Anchoring Phenomena:**
    - "Why Do Railroad Tracks Have Gaps Between Them?" Railroad Tracks are made of metal, usually steel. If the rails were laid without gaps, they could buckle and bend on hot days. Yet we see small gaps between the rail**s**. Driving Questions include: How does heat cause materials to expand, and why do engineers include expansion gaps in structures? Why does the metal expand? What happens to the metal when it gets cold? Do all materials expand at the same rate? Can we measure how much it expands? This will require students to investigate temperature vs heat, thermal energy transfer (conduction, convection, radiation), linear and volumetric thermal expansion, and practical applications in engineering.

Objectives:

- Define temperature in terms of molecular motion. (DOK 1)
- Describe how heat flows. (DOK 2)
- Describe how a thermometer works. (DOK 2)
- Explain the connection between internal energy and heat. (DOK 2)
- Describe how the quantity of heat that enters or leaves a substance is determined. (DOK 2)
- Explain why the specific heat capacities of different substances are different. (DOK 3)
- Describe how water's high specific heat capacity affects climate. (DOK 3)

- Explain how matter changes when heated or cooled. (DOK 2)
- Explain why ice floats on water. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- Teacher Designed "Solar Updraft Tower" Introductory Activity
- Independent Reading of Chapter 21: Temperature, Heat, and Expansion in the textbook.
- Chapter 21 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 21 with student skeleton note page
- Chapter 21 Concept Development Practice Pages.
- "Heat Mixes" Lab.

Correspondent Vocabulary:

- Temperature, Celsius scale, Fahrenheit scale, Kelvin scale, absolute zero, heat, thermal contact, thermal equilibrium, internal energy, calorie, kilocalorie, specific heat capacity, bimetallic strip, thermostat.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Heat Mixes"
  - Model: "Why Do Railroad Tracks Have Gaps Between Them?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 22: Heat Transfer (6 Days)

- **Standard:** 3.2.P.B3: Analyze the factors that influence convection, conduction, and radiation between objects or regions that are at different temperatures.

- **Anchoring Phenomena:**
  - "Why Does a Metal Spoon Get Hot in Soup?" When you place a metal spoon in a bowl of hot soup, after a minute, the handle of the spoon becomes hot—even though it's not directly touching the soup.. Driving Questions include: How does heat travel from the hot soup to the end of the spoon without direct contact with the heat source? Why does a **metal** spoon get hotter than a wooden one? Why

does the soup cool over time even if untouched? What is happening at the particle level inside the spoon? How could you design a spoon that stays cool? This will require students to investigate conduction, convection, and radiation modes of heat transfer.

Objectives:

- Explain how conduction works. (DOK 2)
- Explain how convection works. (DOK 2)
- Explain how heat can be transmitted through empty space. (DOK 3)
- Identify which substances emit radiant energy. (DOK 1)
- Compare the ability of an object to emit radiant energy with its ability to absorb radiant energy. (DOK 2)
- Relate the temperature difference between an object and its surroundings to the rate at which it cools. (DOK 3)
- Identify the main driver of global warming and climate change. (DOK 1)

Core Activities and Corresponding Instructional Methods:

- "Does White Ever Appear Black?" Introductory Activity
- Independent Reading of Chapter 22: Heat Transfer in the textbook.
- Chapter 22 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 22 with student skeleton note page
- Chapter 22 Concept Development Practice Pages.
- "Heat Transfer" Lab.

Correspondent Vocabulary:

- Conduction, conductors, insulator, convection, radiation, radiant energy, stellar radiation, terrestrial radiation, Newton's law of cooling, greenhouse effect.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Heat Transfer"
  - Model: "Why Does a Metal Spoon Get Hot in Soup?"
  - Final Exam

- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.

Chapter 24: Thermodynamics (6 Days)

- **Standard:** 3.2.9-12.R: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
    - **Clarifying Statement:**
        - Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water..
    - **Assessment Boundary:**
        - Assessment is limited to investigations based on materials and tools provided to students.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Planning and Carrying Out Investigations	● Conservation of Energy and Energy Transfer ● Energy in Chemical Processes	● Systems and System Models

- **Anchoring Phenomena:**
    - "How Does a Refrigerator Keep Food Cold?" How does a refrigerator keep food cold while releasing warm air into the room.. Driving Questions include: How can a refrigerator remove heat from the inside and dump it into the surrounding room? Why does the back of the fridge feel warm? Why does opening the door waste energy? Why does a fridge run more in summer? Why can't you cool a room by leaving the fridge door open? This will require students to investigate all four laws of thermodynamics and how they connect to the operation of a refrigerator.

Objectives:

- Describe what happens to the temperature of a substance when the thermal motion of the atoms approaches zero. (DOK 2)
- State the first law of thermodynamics. (DOK 1)

- Describe the effect of adiabatic compression on a gas. (DOK 2)
- State the second law of thermodynamics. (DOK 1)
- Explain how the second law of thermodynamics applies to heat engines. (DOK 3)
- Describe what happens to the orderly state of any natural system. (DOK 2)
- Describe what happens to the entropy of any system. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "Can Temperature Change Without Heat Transfer?" Introductory Activity
- Independent Reading of Chapter 24: Thermodynamics in the textbook.
- Chapter 24 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 24 with student skeleton note page
- Chapter 24 Concept Development Practice Pages.
- "Laws of Thermodynamics" Lab.

Correspondent Vocabulary:

- Thermodynamics, absolute zero, first law of thermodynamics, adiabatic, second law of thermodynamics, heat engine, Carnot efficiency, entropy.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Laws of Thermodynamics"
  - Model: "Can Temperature Change Without Heat Transfer?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 25: Vibrations and Waves (6 Days)

- **Standard:** 3.2.9-12.T: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
    - **Clarifying Statement:**
        - Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.
    - **Assessment Boundary:**
        - Assessment is limited to algebraic relationships and describing those relationships qualitatively.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Using Mathematics and Computational Thinking	● Wave Properties	● Cause and Effect

- **Anchoring Phenomena:**
    - "Why do you hear thunder after you see lightning?" During a thunderstorm, you see a bright flash of lightning, but the sound of thunder arrives several seconds later. Sometimes the delay is short, sometimes it's long. Driving Questions include: If light and sound both come from the same event, why don't we experience them at the same time?? This will require students to investigate wave types: mechanical (sound) vs electromagnetic (light), wave speed: why light travels faster than sound, medium dependence: why sound needs air but light doesn't, energy transfer: waves carry energy, not matter, frequency & wavelength: extend into sound pitch and light color, and reflection & interference: echoes and thunder rumbling.

Objectives:

- Describe the period of a pendulum. (DOK 1)
- Describe the characteristics and properties of waves. (DOK 2)
- Describe wave motion. (DOK 2)
- Describe how to calculate the speed of a wave. (DOK 2)
- Give examples of transverse waves. (DOK 1)
- Give an example of a longitudinal wave. (DOK 1)
- Explain what causes interference patterns. (DOK 3)
- Describe how a standing wave occurs. (DOK 2)
- Describe how the apparent frequency of waves change as a wave source moves. (DOK 3)
- Describe bow waves. (DOK 2)
- Describe sonic booms. (DOK 2)

Core Activities and Corresponding Instructional Methods:

- "What Are Standing Waves?" Introductory Activity
- Independent Reading of Chapter 25: Vibrations and Waves in the textbook.
- Chapter 25 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 25 with student skeleton note page
- Chapter 25 Concept Development Practice Pages.
- "Tick Tock" Pendulum Lab.

Correspondent Vocabulary:

- Vibration, wave, period, simple harmonic motion, sine curve.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Tick Tock" Pendulum
  - Model: "Why do you hear thunder after you see lightning?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 32: Electrostatics (7 Days)

- **Standard:** 3.2.9-12.L: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
  - **Clarifying Statement:**
    - Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.
  - **Assessment Boundary:**
    - Assessment is limited to systems with two objects.
- **Standard:** 3.2.9-12.S: 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.
  - **Clarifying Statement:**

        - Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.
    - **Assessment Boundary:**
        - Assessment is limited to systems with two objects.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Using Mathematics and Computational Thinking ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena ● Developing and Using Models	● Types of Interactions ● Relationship Between Energy and Forces	● Patterns ● Cause and Effect

- **Anchoring Phenomena:**
    - "The Balloon That Sticks… and Repels" A balloon is first rubbed on someone's hair, then the balloon is placed against a wall—and it *sticks*. A second charged balloon is brought near the first—and they *repel* each other. Small bits of paper or a thin stream of water are attracted to the balloon. Driving Questions include: How can an object cause attraction, repulsion, and even stick to a wall without glue? This will require students to investigate electric charge (positive/negative), charging by friction (triboelectric effect), conservation of charge, forces at a distance (electric force), polarization and induced charge, and conductors vs. insulators

Objectives:

- Describe the fundamental rule at the base of all electrical phenomena. (DOK 1)
- Explain how an object becomes electrically charged. (DOK 2)
- Describe Coulomb's law. (DOK 1)
- Distinguish between a good conductor and a good insulator. (DOK 2)
- Describe two ways electric charges can be transferred. (DOK 1)
- Describe what happens when a charged object is placed near a conducting surface. (DOK 2)
- Describe what happens when an insulator is in the presence of a charged object. (DOK2)

Core Activities and Corresponding Instructional Methods:

- "How Can an Object Become Electrically Charged?" Introductory Activity
- Independent Reading of Chapter 32: Electrostatics in the textbook.
- Chapter 32 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 32 with student skeleton note page

- Chapter 32 Concept Development Practice Pages.
- "Static Cling" Lab.

Correspondent Vocabulary:

- Electrostatics, electrical forces, charge, conservation of charge, Coulomb's law, coulomb, conductor, insulator, semiconductor, induced, induction, grounding, electrically polarized.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Static Cling"
  - Model: "The Balloon That Sticks… and Repels"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 33: Electric Fields and Potential (7 Days)

- **Standard:** 3.2.9-12.L: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
  - **Clarifying Statement:**
    - Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.
  - **Assessment Boundary:**
    - Assessment is limited to systems with two objects.
- **Standard:** 3.2.9-12.S: 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.
  - **Clarifying Statement:**
    - Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.

- **Assessment Boundary:**
  - Assessment is limited to systems with two objects.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Using Mathematics and Computational Thinking ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena ● Developing and Using Models	● Types of Interactions ● Relationship Between Energy and Forces	● Patterns ● Cause and Effect

- **Anchoring Phenomena:**
  - "Why Does Lightning Take the Path It Does?" Lightning doesn't travel in a straight line—it branches and zigzags. It tends to strike the *tallest* or *most pointed* objects. The discharge happens suddenly after a buildup. Sparks in a classroom demo behave similarly on a smaller scale. Driving Questions include: How does electricity "decide" where to go, and why does it move the way it does? This will require students to investigate **Electric Fields (**Charges create an invisible influence in space, Field direction explains *why* charges move the way they do, Field strength varies with position (stronger near sharp points); **Electric Potential (Voltage) (**Lightning is driven by a **potential difference** between cloud and ground, Charges move from high potential to low potential, The spark represents rapid release of stored electrical energy.); and **Field–Potential Connection (**Electric field = how potential changes in space, Steeper potential differences create stronger fields which create more dramatic motion)

Objectives:
- Describe how to measure the strength of an electric field at different points. (DOK 2)
- Describe how electric fields are represented by vectors and by electric field lines. (DOK 2)
- Describe how objects can be completely shielded from electric fields. (DOK 2)
- Explain why a charged object in an electric field is considered to have electrical potential energy. (DOK 2)
- Distinguish between electrical potential energy and electric potential. (DOK 2)
- Describe how electrical energy can be stored. (DOK 2)
- Describe the operation of a Van de Graaff generator. (DOK 2)

Core Activities and Corresponding Instructional Methods:
- "What Is Electric Shielding?" Introductory Activity
- Independent Reading of Chapter 33: Electric Fields and Potential in the textbook.

- Chapter 33 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 33 with student skeleton note page
- Chapter 33 Concept Development Practice Pages.
- "Capacitor" Lab.

Correspondent Vocabulary:

- Electric field, electrical potential energy, electric potential, volt, voltage, capacitor.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Capacitor"
  - Model: "Why Does Lightning Take the Path It Does?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 34: Electric Current (7 Days)

- **Standard:** 3.2.9-12.S: 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.
  - **Clarifying Statement:**
    - Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.
  - **Assessment Boundary:**
    - Assessment is limited to systems with two objects.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Developing and Using Models	● Relationship Between Energy and Forces	● Cause and Effect

- **Anchoring Phenomena:**
  - "Why Does One Bulb Get Dimmer When You Add Another?" Set up a simple circuit with a battery and one light bulb. The bulb glows brightly. Then modify the circuit to add a **second identical bulb in series.** Both bulbs become dimmer. Rewire the bulbs **in parallel** - both bulbs are bright again. Driving Questions include: Why does adding another bulb sometimes make lights dim—and other times not? This will require students to investigate Electric Current (Current is the flow of charge through a circuit. Same current flows through all components in a series circuit.); Circuit Structure (Series vs. parallel circuits behave fundamentally differently. Pathways determine how charge flows.); Resistance (Adding components in series increases total resistance. Resistance affects how much current flows.); Energy Transfer (Bulb brightness relates to energy transferred per second (power). Energy from the battery is distributed differently depending on the circuit.)

Objectives:
- Describe the flow of electric charge. (DOK 1)
- Describe what is happening inside a current-carrying wire. (DOK 2)
- Give examples of voltage sources. (DOK 1)
- Describe the factors that affect the resistance of a wire. (DOK 2)
- Describe Ohm's law. (DOK 1)
- Explain the causes of electric shock. (DOK 2)
- Distinguish between DC and AC (DOK 2).
- Describe how AC is converted to DC. (DOK 2)
- Describe the drift speed of conduction electrons in a current-carrying wire. (DOK 2)
- Identify the source of conduction electrons in a circuit. (DOK 1)
- Relate the electric power used by a device to current and voltage. (DOK 2)

Core Activities and Corresponding Instructional Methods:
- "How Can You Make a Simple Voltage Source?" Introductory Activity
- Independent Reading of Chapter 34: Electric Current in the textbook.
- Chapter 34 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 34 with student skeleton note page
- Chapter 34 Concept Development Practice Pages.
- "Ohm's Law" Lab.

Correspondent Vocabulary:

- Potential difference, electric current, ampere, voltage source, electric resistance, superconductivity, ohm, Ohm's law, direct current, alternating current, diode, electric power.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Ohm's Law"
  - Model: "Why Does One Bulb Get Dimmer When You Add Another?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.
  - MP3 Culminating Project: Insulate A Box: students compete to create the most efficient insulating top made of recycled materials for an insulated heat box.

Unit 4: Magnetism and Nuclear Physics (45 Days)

Chapter 35: Electric Circuits (7 Days)

- **Standard:** 3.2.9-12.S: 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.
  - **Clarifying Statement:**
    - Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.
  - **Assessment Boundary:**
    - Assessment is limited to systems with two objects.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Developing and Using Models	● Relationship Between Energy and Forces	● Cause and Effect

- **Anchoring Phenomena:**
  - "Why Does a Circuit Breaker Trip?" A circuit breaker on a power strip tripping when too many devices are plugged in. Driving Questions include: What causes circuits to overload? This will require students to investigate current limits, resistance and power, and safety devices (fuses/breakers).

Objectives:
- Describe the configuration of a working circuit. (DOK 2)
- Explain how current can be turned on or off in a circuit, and how electrical devices can be connected in a circuit. (DOK 3)
- Describe the characteristics of a series circuit. (DOK 2)
- Describe the characteristics of a parallel circuit. (DOK 2)
- Interpret circuit diagrams. (DOK 2)
- Determine the equivalent resistance of circuits having two or more resistors. (DOK 3)
- Explain the cause and prevention of overloading household circuits. (DOK 3)

Core Activities and Corresponding Instructional Methods:
- "What Does It Take to Light a Lightbulb?" Introductory Activity
- Independent Reading of Chapter 35: Electric Circuits in the textbook.
- Chapter 35 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 35 with student skeleton note page
- Chapter 35 Concept Development Practice Pages.
- "Electric Circuits" Lab.

Correspondent Vocabulary:
- Circuit, in series, in parallel, series circuit, parallel circuit, schematic diagram.

Assessments:
- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.

    - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
    - Teacher questioning and observation.
    - Define vocabulary words for this unit.
- **Summative:**
    - Common Assessment Chapter Test
    - Laboratory Investigation: "Electric Circuits"
    - Model: "Why Does a Circuit Breaker Trip?"
    - Final Exam
- **Correctives:**
    - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
    - Additional Think & Explain questions from the textbook.

Chapter 36: Magnetism (7 Days)

- **Standard:** 3.2.P.B4: Explain how stationary and moving particles result in electricity and magnetism.
- **Anchoring Phenomena:**
    - "How Does a Train Float?" A maglev train—a train that floats above the track with no visible support and moves at high speeds. Driving Questions include: How can a massive train float and move without touching the track? This will require students to investigate magnetic forces (attraction vs. repulsion), magnetic fields and field interactions, electromagnets (current to magnetic field), induction (changing magnetic fields to current), Lenz's Law (opposition to change), and applications: levitation, propulsion, and stability.

Objectives:

- Explain how magnetic poles affect each other. (DOK 2)
- Describe the magnetic field in the space around a magnet. (DOK 2)
- Describe how magnetic fields are produced. (DOK 2)
- Describe how to make a permanent magnet. (DOK 2)
- Describe the magnetic field produced by a current-carrying wire. (DOK 2)
- Describe how a magnetic field exerts a force on a charged particle in the field. (DOK 3)
- Describe how current is affected by a magnetic field. (DOK 3)
- Describe how a galvanometer and a motor work. (DOK 3)
- Suggest a possible cause for Earth's magnetic field. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "What Does a Magnetic Field Look Like?" Introductory Activity
- Independent Reading of Chapter 36: Magnetism in the textbook.
- Chapter 36 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 36 with student skeleton note page
- Chapter 36 Concept Development Practice Pages.
- "Magnetism" Lab.

Correspondent Vocabulary:

- Magnetic pole, magnetic field, magnetic domain, electromagnet.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Magnetism"
  - Model: "How Does a Train Float?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 37: Electromagnetic Induction (7 Days)

- **Standard:** 3.2.9-12.M: 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.
  - **Clarifying Statement:**
    - N/A
  - **Assessment Boundary:**
    - Assessment is limited to designing and conducting investigations with provided materials and tools..

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Planning and Carrying Out Investigations	● Types of Interactions ● Definitions of Energy	● Cause and Effect

- **Anchoring Phenomena:**
  - "How Does Electricity Turn Into Motion?" How devices like a fan or a blender use electricity to spin. Driving Questions include: How can electricity cause something to spin or move? This will require students to investigate how electric current produces magnetic fields, how magnetic fields exert forces on moving

charges, interactions between magnetic fields cause motion, energy transformations (electrical to mechanical), and role of components: coils, magnets, commutators.

Objectives:

- Describe how voltage is induced in a coil of wire. (DOK 3)
- State and explain Faraday's law. (DOK 3)
- Describe how a generator works. (DOK 3)
- Describe how a magnetic field affects a moving charge. (DOK 3)
- Describe how a transformer works. (DOK 3)
- Explain why almost all electrical energy is sold in the form of alternating current. (DOK 3)
- Explain how an electric field creates a magnetic field. (DOK 3)
- Describe electromagnetic waves. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "Can You Create an Electric Current Without a Battery?" Introductory Activity
- Independent Reading of Chapter 37: Electromagnetic Induction in the textbook.
- Chapter 37 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 37 with student skeleton note page
- Chapter 37 Concept Development Practice Pages.
- "Motors and Generators" Lab.

Correspondent Vocabulary:

- Electromagnetic induction, Faraday's law, generator, transformer.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Motors and Generators"
  - Model: "How Does Electricity Turn Into Motion?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 38: The Atom and the Quantum (8 Days)

- **Standard:** 3.2.9-12.V: 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.
    - **Clarifying Statement:**
        - Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.
    - **Assessment Boundary:**
        - Assessment does not include using quantum theory.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Engaging in Argument From Evidence ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	● Wave Properties ● Electromagnetic Radiation	● Systems and System Models

- **Anchoring Phenomena:**
    - "Why Do Neon Lights Glow in Different Colors?" How different glowing gas discharge tubes emit distinct colors—bright red-orange, blue, purple, etc.. Driving Questions include: Why do different gases produce different colors of light when electricity passes through them? This will require students to investigate atomic structure (atoms have internal structure (electrons, nucleus); electrons exist in specific energy levels), Energy Quantization (electrons can only occupy certain energies (not continuous); Introduce idea of "energy levels" like steps on a ladder), Electron Transitions (electricity excites electrons to higher energy levels; when electrons fall back down, they emit light); Light as Energy Packets (Photons) (each transition releases a specific energy of light, different energies create different colors), and Atomic Fingerprints (each element has unique energy levels which creates unique emission spectrum - this explains why each gas glows a different color).

Objectives:

- Describe the two primary models of light. (DOK 1)
- Explain how the energy of a photon is related to its frequency. (DOK 2)
- Describe what the photoelectric effect suggests about the way light interacts with matter. (DOK 2)
- Explain what causes light to behave like a wave and what causes light to behave like a particle. (DOK 3)

- Describe what de Broglie suggested about all matter. (DOK 1)
- Describe electron orbits according to de Broglie's theory of matter waves. (DOK 2)
- Explain what determines the radii of the electron orbits in the Bohr model of the atom. (DOK 3)
- Describe the laws governing subatomic interactions. (DOK 2)
- Explain what determines predictability in orderly systems. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "How Can Waves Behave as Particles and Particles Behave as Waves?" Introductory Activity
- Independent Reading of Chapter 38: The Atom and The Quantum in the textbook.
- Chapter 38 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 38 with student skeleton note page
- Selected Check Concepts and Think & Explain questions
- Chapter 38 Concept Development Practice Pages.
- "PhET Photoelectric" Lab.

Correspondent Vocabulary:

- Quantum, photon, Planck's constant, photoelectric effect, quantum mechanics, quantum physics.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "PhET Photoelectric"
  - Model: "Why Do Neon Lights Glow in Different Colors?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 39: The Atomic Nucleus and Radioactivity (8 Days)

- **Standard:** 3.2.9-12.W: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
    - **Clarifying Statement:**
        - Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias..
    - **Assessment Boundary:**
        - Assessment is limited to qualitative descriptions.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Obtaining, Evaluating, and Communicating Information	● PS4.B: Electromagnetic Radiation	● Cause and Effect

- **Anchoring Phenomena:**
    - "Why is a place like Chernobyl still dangerous decades after the explosion?" In 1986, a reactor explosion at the Chernobyl Nuclear Power Plant released invisible substances into the environment. Today—nearly 40 years later—some areas are still unsafe for humans to live in. Plants grow, animals live there, but radiation remains. Driving Questions include: How can something invisible continue to affect matter and living organisms for so long? This will require students to investigate Structure of the atomic nucleus, radioactive decay (alpha, beta, gamma), half-life and why radiation persists, Nuclear stability vs. instability, Energy released from nuclear changes, and biological effects of radiation.

Objectives:

- Describe the role of neutrons in atomic nuclei. (DOK 1)
- Distinguish among the three types of radiation given off by radioactive elements. (DOK 2)
- Explain the factors that determine the penetrating power of radiation. (DOK 2)
- Explain how the isotopes of an element are similar and different. (DOK 2)
- Describe how external conditions affect radioactive decay rates. (DOK 2)
- Explain the effect of radioactive decay on an isotope. (DOK 2)
- Identify which elements have been produced through artificial transmutation. (DOK 1)
- Explain how scientists can determine the age of carbon- containing artifacts. (DOK 3)
- Explain how scientists date very old, nonliving things. (DOK 3)
- Describe some uses for radioactive isotopes. (DOK 1)

- Identify sources of natural radiation. (DOK 1)

Core Activities and Corresponding Instructional Methods:

- "How Do You Model Exponential Growth and Decay?" Introductory Activity
- Independent Reading of Chapter 39: The Atomic Nucleus and Radioactivity in the textbook.
- Chapter 39 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 39 with student skeleton note page
- Chapter 39 Concept Development Practice Pages.
- "Modeling Radioactive Decay & Half-Life" Lab.

Correspondent Vocabulary:

- Nucleons, strong force, radioactive, radiation, isotope, atomic number, atomic mass number, half-life, transmutation.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Modeling Radioactive Decay & Half-Life"
  - Model: "Why is a place like Chernobyl still dangerous decades after the explosion?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.

Chapter 40: Nuclear Fission and Fusion (8 Days)

- **Standard:** 3.2.9-12.W: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
    - **Clarifying Statement:**
        - Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias..
    - **Assessment Boundary:**
        - Assessment is limited to qualitative descriptions.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
● Obtaining, Evaluating, and Communicating Information	● Electromagnetic Radiation	● Cause and Effect

- **Anchoring Phenomena:**
    - "Why do the stars shine and nuclear power plants produce energy?" Stars, including our Sun, release enormous amounts of energy that have powered life on Earth for billions of years; on Earth, humans have built nuclear reactors that produce energy by splitting atoms; both stars and reactors release energy, but the processes behind them are different, invisible, and involve changes in the atomic nucleus. Driving Questions include: How can rearranging the nucleus of an atom release so much energy? Why do some reactions happen naturally in stars but need special conditions on Earth? What makes fusion different from fission in terms of energy, products, and risks? This will require students to investigate Structure of the atomic nucleus and binding energy, nuclear fission: splitting heavy nuclei like uranium or plutonium, nuclear fusion: combining light nuclei like hydrogen isotopes, energy release, mass-energy equivalence, and mass defect, chain reactions and reactor control, natural vs. artificial nuclear processes, and applications: power generation, bombs, medical isotopes.

Objectives:

- Describe the role of neutrons in causing and sustaining nuclear fission. (DOK 1)
- Describe the conditions necessary to sustain a chain reaction. (DOK 2)
- Explain how nuclear fission can be controlled in a reactor. (DOK 2)
- Describe the radioactivity of plutonium. (DOK 1)
- Distinguish between a uranium-based fission reactor and a breeder reactor. (DOK 2)
- Describe the equivalence of mass and energy. (DOK 2)
- Compare the total mass of the products of fusion to the mass of the nuclei that fused. (DOK 2)

- Explain why thermonuclear fusion reactions are so difficult to carry out. (DOK 3)

Core Activities and Corresponding Instructional Methods:

- "How Can You Model Nuclear Reactions?" Introductory Activity
- Independent Reading of Chapter 40: Nuclear Fission and Fusion in the textbook.
- Chapter 40 Exercises Sheet consisting of reading questions.
- Lecture on Chapter 40 with student skeleton note page
- Chapter 40 Concept Development Practice Pages.
- "Modeling Nuclear Fission, Chain Reactions, and Fusion Energy" Lab.

Correspondent Vocabulary:

- Nuclear fission, chain reaction, critical mass, breeder reactor, nuclear fusion, thermonuclear fusion.

Assessments:

- **Diagnostic:**
  - Introduction of the phenomenon and Driving Question Board.
  - Student performance on Introductory Activity and Exercises.
  - Teacher questioning and observation.
  - Student responses to Warmup Questions, Next-Time Questions, and selected Think & Explain questions.
- **Formative:**
  - Student performance on Concept Development Practice Pages.
  - Student performance on selected Think & Rank, Plug & Chug, and Think & Solve questions.
  - Teacher questioning and observation.
  - Define vocabulary words for this unit.
- **Summative:**
  - Common Assessment Chapter Test
  - Laboratory Investigation: "Modeling Nuclear Fission, Chain Reactions, and Fusion Energy"
  - Model: "Why do the stars shine and nuclear power plants produce energy?"
  - Final Exam
- **Correctives:**
  - Supplemental Practice Pages constructed to address areas of student weakness.
- **Extensions:**
  - Additional Think & Explain questions from the textbook.
  - MP4 Culminating Project: Build a Motor: Similar to https://foundation.asnt.org/resources/education/ndt-classroom-experiments/electric-motor.

Optional Chapters to cover if time permits: Chapter 15 Special Relativity—Space and Time, Chapter 16 Relativity—Momentum, Mass, Energy, and Gravity, Chapter 19 Liquids, Chapter 26 Sound, Chapter 27 Light, Chapter 28 Color, Chapter 29 Reflection and Refraction, Chapter 30 Lenses, Chapter 31 Diffraction and Interference.