

Unit 04: Energy Transformation

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Course(s):
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Standards Alignment

New Jersey Student Learning Standards

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems.

Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Select appropriate tools to collect, record, analyze, and evaluate data.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Key Ideas and Details

- LA.K-12.NJSLSA.R1 Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
- LA.K-12.NJSLSA.R2 Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
- LA.K-12.NJSLSA.R3 Analyze how and why individuals, events, and ideas develop and interact over the course of a text.

Craft and Structure

- LA.K-12.NJSLSA.R4 Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
- LA.K-12.NJSLSA.R6 Assess how point of view or purpose shapes the content and style of a text.
- LA.K-12.NJSLSA.R8 Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
- LA.K-12.NJSLSA.R9 Analyze and reflect on how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.
- LA.K-12.NJSLSA.R10 Read and comprehend complex literary and informational texts independently and proficiently with scaffolding as needed.

Reading Science and Technical Subjects

- LA.RST.11-12.1 Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
- LA.RST.11-12.2 Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- LA.RST.11-12.3 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.
- LA.RST.11-12.4 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.
- LA.RST.11-12.6 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.
- LA.RST.11-12.8 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.
LA.RST.11-12.9	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.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
SCI.HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
SCI.HS-ETS1	Engineering Design
SCI.HS-PS3	Energy
SCI.HS-PS2	Motion and Stability: Forces and Interactions
SCI.HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
SCI.HS-PS2-1	Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Integration of Career Readiness, Life Literacies and Key Skills

CRP.K-12.CRP1	Act as a responsible and contributing citizen and employee.
CRP.K-12.CRP2	Apply appropriate academic and technical skills.
CRP.K-12.CRP3	Attend to personal health and financial well-being.
CRP.K-12.CRP4	Communicate clearly and effectively and with reason.
CRP.K-12.CRP5	Consider the environmental, social and economic impacts of decisions.
CRP.K-12.CRP6	Demonstrate creativity and innovation.
CRP.K-12.CRP7	Employ valid and reliable research strategies.
CRP.K-12.CRP8	Utilize critical thinking to make sense of problems and persevere in solving them.
CRP.K-12.CRP9	Model integrity, ethical leadership and effective management.
CRP.K-12.CRP10	Plan education and career paths aligned to personal goals.
CRP.K-12.CRP11	Use technology to enhance productivity.
CRP.K-12.CRP12	Work productively in teams while using cultural global competence.

Technology / Integration of Computer Science and Design Thinking

Interdisciplinary Connections: NJSLs for ELA, Social Studies, Science and/or Math Section

Integration of Diversity, Equity and Inclusion; Climate Change; Informational and Media Literacy

see Crosswalks

21st Century Life and Careers

Stage I: Desired Results

Transfer/Overview/Rationale

Transfer / Overview / Rationale

Unit Rationale

The purpose of this unit...

Meaning

Essential Questions

Essential Questions

How does design impact strength?

How are rates encountered in everyday life?

What happens to the energy in a system?

What causes something to move?

Why is math essential to the understanding of science?

Enduring Understanding/Indicators of Understanding

Enduring Understanding/Indicators of Understanding

Forces cause change in motion and surround us in everyday life.

Design influences strength

Events involving rates are encountered every day.

Energy readily transforms from one form to another, but the total energy of a system cannot change.

Forces are an inescapable part of our everyday activities

An unbalanced force causes whatever it acts on to move

Mathematics often is essential for the understanding of technology use

Acquisition (Student Learning Objectives)

Knowledge

Knowledge

Students will know...

Students will know the following terms:

- energy
- potential energy
- kinetic energy
- joule
- mass
- gravity
- height
- velocity
- KE/PE transformations
- centripetal force
- basic parts of a trebuchet
- historical uses of a trebuchet
- how a trebuchet works
- the forces acting on the trebuchet and the projectile
- basics of projectile motion
- how to calculate projectile motion
- how gravity influences projectile motion

Skills

Skills

Student will be skilled at ...

Students will be able to do the following:

- calculate PE using mass, gravity and height
- calculate KE using mass and velocity
- interpret the KE and PE formulas
- design a working and testable rollercoaster with a creative feature
- identify KE and PE transformations on the rollercoaster
- Use the rollercoaster tycoon program to design a rollercoaster on the computer
- identify the forces acting on the trebuchet and the projectile
- construct a working trebuchet to propel a projectile to a target
- orient a trebuchet to cause the projectile to hit the center of the target
- measure the distance traveled by the projectile
- calculate the time in the air of the projectile

Stage 3: Learning Plan

Resource and Mentor Texts

Resources and Mentor Texts

Gonick, Larry & Art Huffman. The Cartoon Guide to Physics. HarperCollins Publishers, 1990.

How roller coasters work ~ You tube: <http://www.youtube.com/watch?v=7Tredv0Yq1M>

Trebuchet Notes Packet

The Lord of the Rings DVD

Trebuchet User's Guide, PITSCO

Formative Assessment Strategies

Formative Assessment Strategies

KE & PE Changes discussion

Film Clip Discussion

Teacher observations/questions during construction

Learning Activities/Unit of Study

Learning Activities/Unit of Study

Rollercoasters

Day 1:

- Introduction to Rollercoasters
- ***KE & PE Changes
- ***Design discussion
- How do rollercoasters work? Video ~ Youtube
- Project
- ***Introduction
- ***Design

Day 2:

- Project
- ***Design ~ Finish
- ***Construction ~ Begin
- ***Rollercoaster Problems

Day 3:

- Project
- ***Construction
- ***Rollercoaster Problems

Day 4:

- Project
- ***Construction
- ***Rollercoaster Problems

Day 5:

- Project
- ***Construction ~ Finish
- ***Testing ~ Begin

Day 6:

- Project
- ***Testing
- ***Reflection
- ***Finish up rollercoaster problems

Day 7:

- Rollercoaster Tycoon
- Rollercoaster Wii game

Day 8:

- Rollercoaster Tycoon
- Rollercoaster Wii game

Day 9:

- Rollercoaster Tycoon
- Rollercoaster Wii game

Day 10:

- Quiz ~ KE & PE Changes, speed & velocity problems
- Design reflection

Trebuchets

Day 1:

- Film Clip
- Class Discussion
- Notes
- ***Background Information
- ***History
- ***Function
- Introduction to Project

Day 2:

- Notes ~ Projectile Motion
- Projectile Motion Film Clip
- ***Begin Construction

Day 3:

- Notes ~ Calculating Projectile Motion
- ***Construction

Day 4:

- Practice Problems ~ Projectile Motion
- ***Construction

Day 5:

- Finish Practice Problems
- ***Construction

Day 6:

- ***Construction ~ Finish
- ***Pre-testing (if complete)

Day 7:

- ***Testing ~ Distance & Accuracy

Day 8:

- Calculations ~ time in flight
- Reflection on project

Modifications and/or Accommodations

Suggested Modifications (ELL, Sp. Ed, Gifted, At-risk of Failure)

English Language Learners

Native language support: The teacher provides auditory or written content to students in their native language.

Adjusted Speech: The teacher changes speech patterns to increase student comprehension. This could include facing the students, paraphrasing, clearly indicating the most important ideas, and speaking more slowly.

Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.

Front-Loading Vocabulary: The teacher front loads vocabulary. This means providing students with a list of important vocabulary words they will need to know for a book, lesson, etc. prior to the lesson being taught. Including pictures to go with the vocabulary words is also very beneficial for the students.

Special Education Students

Chunking: The teacher presents information in a way that makes it easy for students to understand and remember. Chunking is based on the presumption that our working memory is easily overloaded by excessive detail. The best way to deliver information is to organize it into meaningful units. Because students with special needs get overloaded easily, chunking is an effective strategy to use with them.

Checking for Understanding: It is important to constantly check for understanding, especially for students who have accommodations. Teachers want to make sure students understand the concepts being covered in a way that makes sense to them.

Extra time: The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

Oral Reading: The teacher will read work orally to students. Class work such as tests and literature circles may need to be read aloud to the student.

Timers: The teacher will use timers as an instructional tool. The use of timers is beneficial for students who have trouble completing tasks. Timers can be helpful so the student is aware of how much time they have to complete an assignment.

Students with 504 Plans

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Gifted & Talented Strategies

Extensions/Enrichments: Teachers will provide gifted and talented students with extension/enrichment projects. Students will be challenged to further their understanding, to apply acquired knowledge, and/or to produce something in reference to acquired knowledge.

Modify/Change Activities: Teachers will monitor and modify activities to accommodate those students who need to be challenged further. Additional reading, problem-solving, writing, or project work is necessary for those students who are ready to move on at a rate more accelerated than their peers. In this way, G & T students are provided the same opportunity for support as special needs students.

Students at Risk of School Failure

Directions or Instructions: Make sure directions and/or instructions are given in limited numbers.

Give directions/instructions verbally and in simple written format. Ask students to repeat the instructions or directions to ensure understanding occurs. Check back with the student to ensure he/she hasn't forgotten.

Peer Support: Peers can help build confidence in other students by assisting in peer learning. Many teachers use the 'ask 3 before me' approach. This is fine, however, a student at risk may have to have a specific student or two to ask. Set this up for the student so he/she knows who to ask for clarification before going to you.

Alternate or Modified Assignments: Always ask yourself, "How can I modify this assignment to ensure the students at risk are able to complete it?" Sometimes you'll simplify the task, reduce the length of the assignment or allow for a different mode of delivery. For instance, many students may hand something in, the at-risk student may jot notes and give you the information verbally. Or, it just may be that you will need to assign an alternate assignment.

Increase One to One Time: When other students are working, always touch base with your students at risk and find out if they're on track or needing some additional support. A few minutes here and there will go a long way to intervene as the need presents itself.

Contracts: It helps to have a working contract between you and your students at risk. This helps prioritize the tasks that need to be done and ensure completion happens. Each day write down what needs to be completed, as the tasks are done, provide a checkmark or happy face. The goal of using contracts is to eventually have the student come to you for completion sign-offs.

Hands On: As much as possible, think in concrete terms and provide hands-on tasks. This means a child doing math may require a calculator or counters. The child may need to tape record comprehension activities instead of writing them. A child may have to listen to a story being read instead of reading it him/herself.

Tests/Assessments: Tests can be done orally if need be. Break tests down in smaller increments by having a portion of the test in the morning, another portion after lunch and the final part the next day.

Seating: Seat students near a helping peer or with quick access to the teacher. Those with hearing or sight issues need to be close to the instruction which often means near the front.