

# 04\_Work and Energy

Content Area: **Science**  
Course(s):  
Time Period: **Full Year**  
Length: **4 weeks**  
Status: **Published**

## **General Overview, Course Description or Course Philosophy**

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This course is about the nature of basic things such as motion, force, energy, matter, sound, light, electricity and the composition of atoms. Laboratory experiments, demonstrations, applications to daily life and current topics in physics provide students with an appreciation of this most basic science.

## **OBJECTIVES, ESSENTIAL QUESTIONS, ENDURING UNDERSTANDINGS**

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Essential question:

- How can transforming and transferring energy be useful?

Students will understand:

- Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).
- Laws govern motion on Earth and throughout the universe
- Mathematical representations can be used to understand motion and make predictions about an object's motion

## **CONTENT AREA STANDARDS**

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SCI.HS-PS3-1	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.
SCI.HS-PS3-2	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 position of particles (objects).
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.

## **RELATED STANDARDS (Technology, 21st Century Life & Careers, ELA Companion Standards are Required)**

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SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

MA.K-12.2	Reason abstractly and quantitatively.
PFL.9.1.K12.P.4	Demonstrate creativity and innovation.
MA.K-12.4	Model with mathematics.
MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.WHST.11-12.7	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.
WRK.K-12.P.8	Use technology to enhance productivity increase collaboration and communicate effectively.
TECH.K-12.P.5	Utilize critical thinking to make sense of problems and persevere in solving them.

## **STUDENT LEARNING TARGETS**

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### **Declarative Knowledge**

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Students will know:

- Within a closed, isolated system, energy can change form, but the total energy is constant.
- Energy is the ability to perform work and power is the rate of energy per time
- The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface
- When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. As an object falls, its potential energy decreases as its speed, and consequently its kinetic energy, increases. While an object is falling, some of the object's kinetic energy is transferred to the medium through which it falls, setting the medium into motion and heating it.

The following preconceptions and/or misconceptions will be addressed during the unit:

- Systems consist of a single body only

### **Procedural Knowledge**

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Students will be able to:

### HS-PS3-1

- Students identify and describe the components to be computationally modeled, including:
  1. The boundaries of the system and that the reference level for potential energy = 0 (the potential energy of the initial or final state does not have to be zero)
  2. The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in each component), including a quantification in an algebraic description to calculate the total initial energy of the system
  3. The energy flows in or out of the system, including a quantification in an algebraic description with flow into the system defined as positive
  4. The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system.
- Students use the algebraic descriptions of the initial and final energy state of the system, along with the energy flows to create a computational model (e.g., simple computer program, spreadsheet, simulation software package application) that is based on the principle of the conservation of energy.
- Students use the computational model to calculate changes in the energy of one component of the system when changes in the energy of the other components and the energy flows are known.
- Students use the computational model to predict the maximum possible change in the energy of one component of the system for a given set of energy flows. b Students identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic descriptions of energy changes and flows in the system.

### HS-PS3-2

- Students develop models in which they identify and describe the relevant components, including:
  1. All the components of the system and the surroundings, as well as energy flows between the system and the surroundings
  2. Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system;
  3. Depicting the forms in which energy is manifested at two different scales: macroscopic (such as motion, sound, light, thermal energy, potential energy or energy in fields) and molecular/atomic (such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields (potential energy), and energy in fields
- Students describe the relationships between components in their models, including:
  1. Changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy).
  2. Thermal energy includes both the kinetic and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases.
  3. The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level.
  4. Chemical energy can be considered in terms of systems of nuclei and electrons in electrostatic fields (bonds).
  5. As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields.
- Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system.
- Students use their 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 on both the macroscopic and microscopic scales.

## HS-PS3-3

- Students design a device that converts one form of energy into another form of energy.
- Students develop a plan for the device in which they:
  1. Identify what scientific principles provide the basis for the energy conversion design
  2. Identify the forms of energy that will be converted from one form to another in the designed system
  3. Identify losses of energy by the design system to the surrounding environment
  4. Describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design
  5. Describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risk.
- Students describe and quantify (when appropriate) prioritized criteria and constraints for the design of the device, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost and efficiency of energy conversion.
- Students build and test the device according to the plan.
- Students systematically and quantitatively evaluate the performance of the device against the criteria and constraints.
- Students use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs.

## **EVIDENCE OF LEARNING**

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### **Formative Assessments**

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Strategic questioning

Class/small group discussions

Homework and classwork assignments

Conducting and analyzing labs

### **Summative Assessments**

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- Benchmarks – departmental benchmark given at the end of MP1, MP2, and MP3
- Alternative Assessments
  - Lab inquiries and investigations
  - Lab Practicals

- Exploratory activities based on phenomenon
- Gallery walks of student work
- Creative Extension Projects
- Build a model of a proposed solution
- Let students design their own flashcards to test each other
- Keynote presentations made by students on a topic
- Portfolio

## **RESOURCES (Instructional, Supplemental, Intervention Materials)**

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The Physics Classroom - <http://www.physicsclassroom.com/>

PhET simulations - <https://phet.colorado.edu/>

Pivot - <https://www.pivotinteractives.com/>

Edpuzzle - <https://edpuzzle.com/>

Vernier labs - teacher lab manual available in classroom

## **INTERDISCIPLINARY CONNECTIONS**

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Calculations drive connections with mathematics courses

## **ACCOMMODATIONS & MODIFICATIONS FOR SUBGROUPS**

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See link to Accommodations & Modifications document in course folder.