

Teacher Toolkit - The Basics of Work, Energy, and Power

Objectives:

1. To describe the conditions under which positive and negative work are done and to use the work equation to calculate the amount of work done.
2. To define potential energy, to identify the two forms and the variables that affect the amount of each form, and to calculate the potential energy possessed by an object.
3. To define kinetic energy, to identify the variables that affect the amount, and to calculate the kinetic energy possessed by an object.
4. To identify the two forms of mechanical energy, to distinguish between mechanical and non-mechanical energy, to describe the relationship between mechanical energy and work, and to relate the total mechanical energy (TME) to the amounts of kinetic energy (KE) and potential energy (PE).
5. To distinguish between power and work and to use two power equations to calculate the power.

Readings: [The Physics Classroom Tutorial, Work, Energy and Power Chapter, Lesson 1](#)

Interactive Simulations:

1. PhET: Masses & Springs <http://phet.colorado.edu/en/simulation/mass-spring-lab>
This realistic mass-and-spring simulation is a great way to visualize changing kinetic and potential energy in a spring system. Real-time bar graphs are displayed of KE, Gravitational PE, Elastic PE, and Thermal energy.
2. It's All Uphill <http://www.physicsclassroom.com/Physics-Interactives/Work-and-Energy/Its-All-Uphill>
The It's All Uphill Interactive provides a tool to investigate the effect of an incline angle upon the amount of work (and amount of force) required to pull a cart up the incline at constant speed. Works well on tablets such as the iPad and Chromebooks.
3. PhET Simulation: The Ramp <http://phet.colorado.edu/en/simulation/the-ramp>
In this simulation, students push common objects of various masses up an incline to explore the relationship of applied force, work, and energy. They can control the angle of the ramp, friction, and amount of applied force.
4. Energizer Model <http://www.thephysicsfront.org/items/detail.cfm?ID=8227>
This interactive model explores the relationship between kinetic, potential, and total energy. Students create their own track. Bar graphs of KE, PE, and total energy are displayed in real time alongside the curve.
5. Virtual Trebuchet <http://virtualtrebuchet.com/#simulator>
We like this free simulator because it's simple to use, yet introduces a plethora of conditions that would affect the effectiveness of a trebuchet.

Video and Animation:

1. Energy Transfer in a Trebuchet <http://www.pbslearningmedia.org/resource/hew06.sci.phys.maf.trebuchet/energy-transfer-in-a-trebuchet/>
This short video from PBS Learning Media features a team of engineers who recreate a medieval trebuchet using only technologies available in the Middle Ages. It does a good job of exploring the advantage of the off-center pivot and the purpose of the heavy counterweight (which revolutionized catapult-type projectile warfare).
2. Trebuchet Physics: Make Your Trebuchet Throw Farther <http://youtu.be/8hAX72XgfIU>
We figured you already have your favorite videos of punkin' chunkin' or projectile launching competitions. But you probably haven't seen anything quite like this 6-minute video that explores useful tricks to make a more successful trebuchet design.
3. Smarter Every Day: The Physics of Slingshots <http://youtu.be/1v4TEX2erog?list=UU6107grR14m0o2-emgoDnAA>
Mechanical Engineer Destin Sandlin works with a high-speed Phantom camera to bring you great slow-motion views of slingshots in action. The photography is fantastic, but the physics explanation is where the rubber meets the road in this video.

Related Physics Education Research

<http://www.compadre.org/PER/document/ServeFile.cfm?ID=11936&DocID=2847>
Energy as a Substancelike Quantity that flows: Theoretical Considerations and Pedagogical Consequences, by Eric Brewster, Phys. Rev. ST Phys. Educ. Res. 7 (2), 021006 (2001)

Physlets:

(See the complete toolkit at TPC's Teacher Toolkit website for details.)

1. Physlet Physics: Constant Forces http://www.compadre.org/Physlets/mechanics/illustration6_2.cfm
2. An Operational Definition of Work http://www.compadre.org/Physlets/mechanics/ex6_1.cfm
3. Physlet Physics: Work Done by a Spring http://www.compadre.org/Physlets/mechanics/illustration6_4.cfm

Labs and Investigations:

<http://www.physicsclassroom.com/lab/index.html#energy>

The Physics Classroom, The Laboratory,

1. It's All Uphill
2. It's All Uphill - The Sequel
3. Powerhouse
4. Marble Energy
5. Marble Energy II

Project-Based Learning Module

1. GreenLearning-Canada: Build A Wind Turbine <http://www.re-energy.ca/wind-turbine>
This web page provides step-by-step instructions for building a vertical axis wind turbine. The 17-page construction plans may be freely downloaded and are organized for first-time builders.

Minds On Physics Internet Modules:

<http://www.physicsclassroom.com/mop>

The Minds On Physics Internet Modules are a collection of interactive questioning modules that target a student's conceptual understanding. Each question is accompanied by detailed help.

1. Ass't WE1 - Work
2. Ass't WE2 - Power
3. Ass't WE3 - Kinetic and Potential Energy
4. Ass't WE4 - Total Mechanical Energy

Concept Building Exercises:

<http://www.physicsclassroom.com/curriculum/energy>

The Curriculum Corner, Work, Energy and Power,

1. Work
2. Power
3. Work and Power Calculations
4. Work, Energy and Power, Energy

Problem-Solving Exercises:

<http://www.physicsclassroom.com/calcpad/energy/problems>

1. The Calculator Pad, Work, Energy, and Power, Problems #1 - #14

Science Reasoning Activities:

<http://www.physicsclassroom.com/reasoning/energy>

1. Hot Wheels Stopping Distance

Real Life Connections:

1. Sankey Diagrams <http://www.sankey-diagrams.com/>
This website shares hundreds of Sankey diagrams available for free download and offers links to open source Sankey Diagram builders available for free. Includes keyword-search capabilities.
2. Walk Through a Hydroelectric Plant <http://fwee.org/nw-hydro-tours/walk-through-a-hydroelectric-project/>
This virtual tour takes you through a hydroelectric power plant. It begins as water from a reservoir flows through a large pipe at the bottom of a dam and acts to power a giant turbine.

Interactive Homework Problems

(See the complete toolkit at TPC's Teacher Toolkit website for details.)

1. PER Interactive Problem: Bobsled <http://per.physics.illinois.edu/per/IE/ie.pl?phys101/ie/06/bobsled>
2. PER Interactive Problem: Pulley and Two Masses <http://per.physics.illinois.edu/per/IE/ie.pl?phys101/ie/06/p2m>

Common Misconceptions

(See the complete toolkit at TPC's Teacher Toolkit website for details.)

1. Work is Always Done When an Object Moves
2. Work is Always Done When a Force is Applied
3. Confusion of Power and Work
4. An Object At Rest Does Not Have Energy

Standards:**A. Next Generation Science Standards (NGSS)**

Performance Expectations – Physical Science: Energy

Middle School MS-PS3-1, High School HS-PS3-1 and HS-PS3-3

Disciplinary Core Ideas – Physical Science: Energy – Definitions of Energy

Middle School MS.PS3.a.iii and MS.PS3.a.iv, High School HS-PS3.a.ii and HS-PS3.a.iii:

Disciplinary Core Ideas – Phys. Sci: Energy – Conserv'n of Energy/EnergyTransfer

Middle School MS-PS3.b.i and MS-PS3.c.i, High School HS-PS3.b.ii and PS3.B.iii

Crosscutting Concepts: Patterns, Cause and Effect, Systems and System Models, Energy and Matter

Science and Engineering Practices: Practice #2, #3, #5, and #8

B. Common Core Standards for Mathematics (CC) – Grades 9-12

Standards for Mathematical Practice - MP.1, MP.2, MP.4

High School Algebra: Creating Equations - A-CED

High School Functions: Interpreting Functions - F-IF.4, F-IF.6

High School Functions: Linear, Quadratic, and Exponential Models - F-LE.1.b, F-LE.1.c