

EARTH, WIND, SOLAR & WATER ENERGY
Converting Watts to Kilowatts

Grade 11
Concept: Dimensional Analysis

Mathematics
Level: I/II

Connections to the Energy Lab:

- The Earth Experience focuses on balancing worldwide fossil fuel demands vs. energy output
- The Wind Experience focuses on the different variables that affect wind turbine performance
- The Fire Experience focuses on capturing solar energy via solar panels, solar arrays and solar farms
- The Water Experience focuses on harnessing energy through wave production in open water

General Goal(s) of the Lesson:

Students should be able to...

- Write an amount of power given in watts and kilowatts
- Compare amounts of power given in either unit
- Recognize metric prefixes such as kilo-, mega-, centi-, etc.

Lesson Objectives:

- Discuss units and why they need to be converted from one to another
- Demonstrate the process of converting
- Understand how to compare one unit of measure to another (0.5 KW vs. 100 W – which is bigger?)
(Based on Massachusetts State Standard 12.M.2 for Mathematics)

Assessment Based on Objectives:

- Students will submit an exit slip/assignment with completed conversions
- Calculate: How many 100W light bulbs can a 2KW generator support?

Learning Adaptations:

- Relate to converting $\text{cm} \rightarrow \text{m}$, $\text{in} \rightarrow \text{ft}$

Learning Extensions:

- Compare a gram to kilogram and feel the difference using actual weights
- Multiplying and dividing by powers of 10, ask: Where does the decimal point move?

Resources:

Kilowatts: Webster's Fact and Phrases by Icon Group International (ISBN: 0546796060)
Auto Math Handbook HP by John Lawlor (ISBN: 1557880204)
Jet Learning Laboratory 11th Grade Math Prep: High School Exit Mathematics Challenge Book by Jet Learning Laboratory (ISBN: 1434841251)
Energy Systems and Sustainability by Godfrey Boyle (ISBN: 1099261792)

EARTH, WIND, SOLAR & WATER ENERGY
Converting Joules to Kilowatt-Hours

Grade 11
Concept: Dimensional Analysis

Mathematics
Level: III

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General Goal(s) of the Lesson:

Students should be able to...

- Describe the difference between energy and power
- Use multiple conversion factors to convert from one unit to another
- Compare different quantities of energy

Lesson Objectives:

- Show video and/or image of a power meter outside of a building. Understand the different readings shown on the meter.
- Show ratio methods for converting ex. $10\text{J} \times (1\text{KJ}/1000\text{J})$. Have students explain how multiplying by a conversion factor is a complicated form of multiplying by 1.
- Help students decide which unit should be in the numerator or denominator in order to divide out units that do not appear in the final answer.

(Based on Massachusetts State Standard 12.M.2 for Mathematics)

Assessment Based on Objectives:

- Using multiple conversion factors, determine which quantity is the most energy
- Individual practice converting one unit to another

Learning Adaptations:

- Compare to exchanging money or hourly rates
- Show charts or graphs comparing quantities in J or Kw-h to show that the numbers change in the same way with time, but are different by some factor.

Learning Extensions:

- Multiplying fractions
- Understand multiplying conversion factors is the same as multiplying by 1 (use of the multiplicative identity)

Resources:

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Auto Math Handbook HP by John Lawlor (ISBN: 1557880204)
Jet Learning Laboratory 11th Grade Math Prep: High School Exit Mathematics Challenge Book by Jet Learning Laboratory (ISBN: 1434841251)
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EARTH, WIND, SOLAR & WATER ENERGY
Graphing a Set of Data (x, y)

Grade 11
Concept: Coordinate Planes

Mathematics
Level: I/II

Connections to the Energy Lab:

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General Goal(s) of the Lesson:

Students should be able to...

- Label and scale a set of coordinate axes appropriately, given a set of data
- Produce a scatter plot by plotting points from a set of data
- Evaluate the scale of a given scatter plot (i.e. too small, too big)

Lesson Objectives:

- Show a complete scatter plot (students should identify the scale, axes, and explain individual data points)
- Demonstrate how to plot individual points given a set of labeled axes (ex. plot energy vs. time during the day on axes already labeled)

(Based on Massachusetts State Standard 12.P.10 for Mathematics)

Assessment Based on Objectives:

- Construct a scatter plot for a given set of data
- Exit slip/assignment: Find one thing wrong with this graph
- Scaffolded worksheets: some questions ask to only write in scale while others ask to create a full scatter plot

Learning Adaptations:

- "Crawl before you walk": x before y
- Multiplication table for scaled axes (2, 4, 6 is more useful than 1, 3, 5)

Learning Extensions:

- Find meaning of each data point (At 3 hours on the x-axis, the energy used was 10W on the y-axis)
- Use real life applications (ex. construct a scatter plot of solar panel voltage output vs. temperature)

Resources:

Coordinate Graphing (Teacher Created Resources)
by Edward Housel and Debra J Housel (ISBN: 1420621157)
The Elements of Graphing Data by William Cleveland (ISBN:0963488414)
Pre-Calculus Graphing and Data Analysis: Student Solutions Manual by Michael Sullivan (ISBN: 0136987141)
Homework Helpers: Calculus by Denis Szecsei (ISBN: 1564149145)

EARTH, WIND, SOLAR & WATER ENERGY
Finding the Slope of a Line ($y=mx+b$)

Grade 11
Concept: Coordinate Planes

Mathematics
Level: III

Connections to the Energy Lab:

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General Goal(s) of the Lesson:

Students should be able to...

- Distinguish between a numerical quantity and the rate of change of that quantity
- Identify the sign of the slope of a line given the graph and calculate the magnitude using two points

Lesson Objectives:

- Show graphs of energy. Students should be able to describe when the amount of energy is going up, going down or is static. This corresponds with students qualitatively recognizing the sign of slope from a graph.
- Given two ordered pairs, is the slope of the line through them positive, negative or zero?
(Based on Massachusetts State Standard 12.P.10 for Mathematics)

Assessment Based on Objectives:

- Compare lines of different slopes and determine which one has zero, negative or the greatest magnitude of slope
- Give two points on a line and have students calculate the slope from coordinates or using the graph

Learning Adaptations:

- Students can act out or model positive, negative and zero slopes using their bodies
- Use transparencies or graph paper to show lines of different slopes

Learning Extensions:

- Students should look at a graph of energy output vs. time for a building or type of energy being collected and identify when it is increasing/decreasing or constant. This would also enable the students to calculate the rate of change of energy stored in batteries or provided by power plants.
- This concept can be connected to the derivative in calculus

Resources:

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by Edward Housel and Debra J Housel (ISBN: 1420621157)
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EARTH ENERGY
Proportions and Fractions

Grade 11
Concept: Proportions & Fractions

Mathematics
Level: I/II

Connections to the Energy Lab:

- The Earth Experience focuses on balancing worldwide fossil fuel demands vs. energy output

General Goal(s) of the Lesson:

Students should be able to...

- Explain the concept of a proportion and give an example of a set of numbers that are all in proportion to each other
- Determine a constant of proportionality for a given set of data

Lesson Objectives:

- Show different images in proportion and others out of proportion. Understand the difference.
- Show how a proportionality constant quantifies this relationship ($y = kx$)
(Based on Massachusetts State Standard 12.M.2 for Mathematics)

Assessment Based on Objectives:

- Draw different figures in proportion and verify through measurement
- Given a set of data, calculate the proportionality constant

Learning Adaptations:

- Move an overhead projector closer and further away from the wall to show how the image changes size in proportion

Learning Extensions:

- Scale drawing, (ex. draw an image twice the size of the original)
- Increase/decrease the size of an image on a computer

Resources

Making Sense of Fractions, Ratios and Proportions: 2002 Yearbook by Bonnie Litwiller (ISBN: 0873535197)
Teaching Fractions and Ratios for Understanding by Susan Lamon (ISBN: 0805852107)
Mathematics Teaching Cases: Fractions, Decimals, Ratios and Percents Hard to Teach Hard to Learn? By Donna Goldstein, Carne Barnett-Clarke and Babette Jackson (ISBN: 0435083570)
Real Life Math for Fractions, Ratios and Rates, Grades 9-12 by Tom Campbell (ISBN: 978-0825163203)

EARTH ENERGY
Drawing a Map to Scale

Grade 11
Concept: Proportions & Fractions

Mathematics
Level: III

Connections to the Energy Lab:

- The Earth Experience focuses on balancing worldwide fossil fuel demands vs. energy output

General Goal(s) of the Lesson:

Students should be able to...

- Relate distances on a map to real world distances
- Draw a map to scale given the real world locations

Lesson Objectives:

- Show a map and measure distances on it. Relate these measurements to actual distances.
- Show that distances between objects on a map and in space are in proportion to each other.
(Based on Massachusetts State Standard 12.M.2 for Mathematics)

Assessment Based on Objectives:

- Create a map of the classroom to scale after taking measurements
- Calculate distances using Google Maps for trips around the students' neighborhood
- Give students a map and scale. Ask them to calculate actual distances between objects/locations

Learning Adaptations:

- Zoom in and out of Google Maps. Notice distance is preserved.
- Using floor tiles as a grid, count and measure distances in classroom to construct a map

Learning Extensions:

- Go smaller: Show a microscopic view of a cell and determine distances between organelles

Resources:

Making Sense of Fractions, Ratios and Proportions: 2002 Yearbook by Bonnie Litwiller (ISBN: 0873535197)
Teaching Fractions and Ratios for Understanding by Susan Lamon (ISBN: 0805852107)
Mathematics Teaching Cases: Fractions, Decimals, Ratios and Percents Hard to Teach Hard to Learn? By Donna Goldstein, Carne Barnett-Clarke and Babette Jackson (ISBN: 0435083570)
Real Life Math for Fractions, Ratios and Rates, Grades 9-12 by Tom Campbell (ISBN: 978-0825163203)
Map Scales by Mark Dodson Wade and Jeanne Clidas (ISBN: 978-0516277677)

EARTH & SOLAR ENERGY
Temperature Conversion (C to K)

Grade 11
Concept: Inverse Operations

Mathematics
Level: I/II

Connections to the Energy Lab:

- The Earth Experience focuses on balancing worldwide fossil fuel demands vs. energy output
- The Fire Experience focuses on capturing solar energy via solar panels, solar arrays and solar farms

General Goal(s) of the Lesson:

Students should be able to...

- Explain how different scales of temperature have different uses
- Convert from Kelvin (absolute) scales to Celsius scales and the reverse
- Understand the relationship between a function or operation and its inverse

Lesson Objectives:

- Show a set of temperatures side by side and have students figure out the pattern
- Demonstrate conversions for a few temperatures and show that they are the reverse of each other
- Show the relationship between inverse operations

(Based on Massachusetts State Standard 12.P.5 for Mathematics)

Assessment Based on Objectives:

- Give two temperatures on different scales and compare, or multiply, temperatures and then write them in order of least to greatest
- Show graphs of temperature and determine which one is Celsius and which one is Kelvin
- Exit slip/assignment: Show various temperatures converted between scales

Learning Adaptations:

- Show two scales side by side to show similarities
- Give examples of other pairs of operations that are opposite of each other (ex. multiplication/division, wrapping/unwrapping a gift)

Learning Extensions:

- Relate to Ideal Gas Law, which requires temperature in Kelvin
- Absolute zero in physics has many important meanings and consequences

Resources:

Convert Between Units of Temperature YouTube Teaching Video
<http://www.youtube.com/watch?v=gTckF8WKZgw>
Hands-On General Science Activities With Real-Life Applications: Ready-to-Use Labs, Projects, and Activities for Grades 5-12 (J-B Ed: Hands On) ISBN: 0787997633
Metric Conversions Student Worksheet <http://chemistry.about.com/library/tempconversion.pdf>

EARTH & SOLAR ENERGY

Temperature Conversion (F to K, F to C)

Grade 11

Concept: Inverse Operations

Mathematics

Level: III

Connections to the Energy Lab:

- The Earth Experience focuses on balancing worldwide fossil fuel demands vs. energy output
- The Fire Experience focuses on capturing solar energy via solar panels, solar arrays and solar farms

General Goal(s) of the Lesson:

Students should be able to...

- Understand more complex pairs of inverse operations and be able to relate them to each other through tables and explicit equations
- Write or solve for the inverse of a function
- Convert Celsius to Fahrenheit (and vice versa), Fahrenheit to Kelvin (and vice versa)

Lesson Objectives:

- Show the more general relation between a function and its inverse $f^{-1}(f(x)) = x$
- Give simple examples of function/inverse pairs in equation, table and graphical form. Include cases of functions that do NOT have inverses.
- Show how C to F, F to C, and F to K functions are related to each other using function notation. Demonstrate those conversions.

(Based on Massachusetts State Standard 12.P.5 for Mathematics)

Assessment Based on Objectives:

- Give students temperatures in C, F and K and ask them to convert to different scales (use important temperatures such as boiling point/freezing point of water, body temperature, hi/lo weather temperatures, etc.)
- Give a student a simple function y in terms of x , and have the student write the inverse of the function.

Learning Adaptations:

- Limit conversions to integers to emphasize concept of conversion first, than include decimal values
- Using a digital thermometer, challenge students to "predict" what the other unit setting will read

Learning Extensions:

- Show more abstract examples of functions (ex. $\sin^{-1}x$)
- Relate F to C using the origins of these scales (body temperature, boiling/freezing)
- Students may observe that converting from F to K can be done by function composition.

Resources:

Science Help Online Worksheet For Conversions

<http://www.fordhamprep.org/gcurran/sho/sho/worksheets/worksht29a.htm>

U.S. units of measure and conversion factors:: A tabular summary of U.S. units of measure with reciprocal conversion factors and a graphic chart for temperatures by Samuel Benjamin Ellis