Lesson Plan: Energy Basics

Concepts

1. Energy is the ability to do work and is used in order to perform work.
2. Power is the rate at which work is done.
3. There are mathematical representations of work and power.
4. There are various units of energy, work, and power.

Key Questions

1. How do you describe the relationship between energy, work, and power?
2. How do you represent the relationships between the three, using mathematical formulas?
3. What is the relationship between power in kW and in horsepower?

Student Learning Objectives
The student will be able to define and contrast energy, work, and power.
Given mass, distance, and time, the student will be able to calculate work and power using appropriate units.
Given the conversion formulas, the student will be able to calculate horsepower and kilowatt equivalence.
Students will use measurement tools to apply the concepts of work, power, and energy to a real life example

Educational Standards

- NSES Science (5-8): A1.3, A1.4, A1.5, A1.8, A2.3, B3.1
- NCTM Math (6-8): A1.4, A2.1,A2.2, B1.2, B2.1, B2.3, B3.1, D1.1, D1.2, D2.2, D2.6, E3.1, F2, I3, J3

Anticipatory Set

- The students will have been introduced to the global energy problem and how their choices impact the energy situation.
- The purpose of this lesson is to introduce the students to the basic concepts of energy and to use that knowledge in an experiment.

Key Terms

Force	A force is a push, pull, or twist	=mass x acceleration	Newton (N) =kg/m/s^2
Joule	the SI unit for energy and work.		J = W·s = N·m
Energy	the ability to do work	=power x time	Joule
Work	Work is a force acting over a distance to move an object	= force x distance	Joule (J)
Power	The rate at which work is done	= work / time (or =energy/time)	Watt = J/s
Meter	the SI (Standard International) unit for distance		m
Kilogram	the SI unit for mass		kg
Btu	The amount of energy needed to raise 1 lb of water 1 degree Fahrenheit (1 Btu ~ heat energy from one wooden match)		1 Btu = 1055 Joules
Kilowatt	Typical unit for electrical power		1 kW = 1000 watts
Horse power	Unit for mechanical or electrical power		1 hp = 746 watts
Kilowatt hour	Typical unit for electrical energy		kWh

Teaching Plan:

Day 1:

- Introduce energy with word association brainstorm –
  - What do students think about when they hear the term "Energy?"
  - Where/how do you use energy in your lives? Name a few things that we do that use energy. Can use examples from game.
  - What happens when we don't have access to energy (electric power) (e.g. summer blackout/ice storms)?
  - Lead to concepts of energy in a useful form to provide heat, power or do work for human use.
  - Note – everything is either capable of providing energy or has energy, until there is none left – has been transformed to something else
- (Optional) Hand out vocabulary sheet – indicate that students should fill in as go. Have copy on transparency sheet – fill in definitions and equations in appropriate places as proceed.

- Write definitions and equations on board
    - A force is a push, pull, or twist
        - Force = mass X acceleration
    - Drop a ball . What is pulling it towards the ground? Gravity. Acceleration of gravity (9.81 m/s^2).
    - Energy is the ability to do work
    - Work is a force acting over a distance to move an object
        - Work = force X distance
    - Power is how fast work is done (or the rate at which work is done)
        - $Power = \frac{work}{time} \quad OR \quad Power = \frac{energy\,used}{time}$
- Re-enforce the concept of work with the Student Push/Pull Demo
    - Ask for two volunteers.
    - Have one push against the wall and one push on a chair so that the chair moves at least 0.5 meters.
    - Discuss as a class
        - Did either one or both of these students do any work? The one pushing on the chair did work; the other did not. "Work" requires that an object be moved.
        - Did either of these expend energy? Yes – energy contributes to doing work, but not all energy successfully does work.
- Go over SI Units (System Internationale)
    - We use this so that parts made in the US and in other parts of the world match (an engine built in Japan can fit in a car made in the US since the measurements are the same)
    - Mass → kilogram (kg)
    - Distance→ meters (m)
    - Time → second (s)
    - Velocity → meters per second (m/s)
    - Acceleration → meters per second squared (m/s^2)
    - Energy → Joule (J)
    - Force → Newton (N)
        - A Newton is also a $kg*m/s^2$
        - We determine this by plugging the units into the equation

$$Force = mass * acceleration = kg * \frac{m}{s^2} = \frac{kg * m}{s^2} = N$$

    - Work → Joule (J)

        - A Joule is also a N*m (work = force x distance)
    - Power → Watt (W)
        - A Watt is also a J/s or N*m/s
        - An easy way to remember the Watt is to ask the kids "Watt (What) is the unit of Power?" They like that.
- There are two units that we will use to measure energy
    - British Thermal Unit (BTU): There are 1055 Joules in one BTU. This unit is used when we measure large amounts of energy. For example we would measure the amount of energy is the USA's oil reserves in BTU.
    - Kilowatt Hour (kWh): This is how the electrical energy you use in your home is measured on your electricity bill. It is how many kilowatts you use in an hour.
        - 1000 W = kW
        - energy = power (kW)* time (h)
- Extension – besides electrical energy, what other type of energy does our home consume a lot of in the north? HEAT! does anyone know the energy term used to measure the amount of natural gas we use to heat our homes? Therm. 1 therm = 100,000 BTU.
- Where have you heard the term horsepower?
    - Explain that this is the way that they used to measure power. (James Watt built the first steam engine. When he was selling it, he advertised to farmers and miners that it could give more power than a horse. He said that it had 1.5 horsepower. Although the unit of horsepower is still used today, it does not accurately describe how many horses it replaces. This is because not every horse is the same.)
- Have students run through several examples of work and power. Always ask – is there work being done? If you have time pass out spring scales and have the students experiment. Make sure that you do a few example calculations with them or they will be lost with the homework! Here are a few examples you can use.
    - Jim's daughter has locked herself in the bathroom and his wife is on her way home and sure to be angry. If Jim throws himself against the door with a force of 200 N opening the door 0.5 m in 2 seconds. What is his Work, and Power?

      (answers: W=100 J, P=50 W)
    - A crane is lifting a car that weighs 2000 kg a distance of 5m in 2min (convert to seconds with the class 120s). What is the Force ($g=9.8m/s^2$), Work, and Power?

(answers: F=19600 N, W= 98000 J, P= 816 W or .081 kW)

- Closure
  - Give out “Big Bad Wolf” homework. Assign it to be passed in tomorrow (or following day).
  - Reinforce energy, work, and power
  - Ask – what did we learn today? Can anyone define work, power, energy?

Day 2:

- Have student demonstrate human power experiment – (no measurement)
- Discuss what happened – use discussion to review energy, work, and power– go over equations and units for force, work, power.
  - Work = force x distance
    - Where Force = mass x acceleration
  - Power = work/time
- Ask students – if we wanted to determine how much work student just did, what could we measure? (mass, time, distance – can’t measure force directly in this case)
- Introduce Human Power Activity. This activity will require students to collect data for mass, distance and time. The activity sheet lists equipment needed, but you may want to substitute heavier bottles so the students can “feel” the work they do (2-liter or gallon milk jugs work well).
- Using the data collected in the Activity, calculate average time and apply the appropriate formulas to calculate work and power. Calculate a few of the trials in class, have students finish the calculations for homework.
- Hold up a 60 Watt light bulb and ask if anybody in the class produced enough power to light the bulb (hopefully no one actually does). Ask if they could produce more power possibly with their legs. (Give the example of the human powered bike headlights).
- Ask and/or lead a student (on the board) through a calculation of how many of themselves it would take to light the bulb, based on their power output from the activity.   # of people to light 60 Watt bulb = 60 watts/power from the activity. (For example, if the student’s name was Nate and it took 300 of them to light the bulb, it is therefore a 300 natepower bulb.)
- If time allows, convert watts to horsepower in activity.

Day 3:

- You will probably need to use the beginning of this class to wrap up the Human Power Activity.
- Go over/collect big bad wolf homework. Make sure students used right equations, units. Newtons might be especially difficult.
- You may want to use the Energy Basics power point to review

- If you have extra time just do more example calculations.

Day 4:

- Allow at least half the period for the students to complete the Energy Basics Assessment

Resources (included below)

Human Power Activity
Big Bad Wolf Homework
Big Bad Wolf Homework Sheet
Big Bad Wolf Answer Key
Vocabulary sheet
Energy Basics Assessment

Assessments

Big Bad Wolf Homework
Human Power Activity Sheet
Energy Basics Assessment

URL

All lesson plans in this unit are included at
http://www.clarkson.edu/highschool/k12/project/energysystems.html

This URL has been included in the Engineering Pathways web site (http://www.engineeringpathway.com/ep/index.jhtml) and can be found with a search on "energy choices."

Owner

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Contributors

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Activity: Human Power

Purpose

Work and power are important concepts that deal with energy. Work is a force over a given distance and power is the amount of work done in an amount of time. The goal of this experiment is to get familiar with these concepts.

Equipment

1. Scale
2. Stopwatch
3. large bottle filled with water
4. meter stick
5. pole
6. rope

Procedure

Set up the experiment:

1. Split into groups of 3-4 students.
2. Collect all equipment and materials necessary to conduct the activity.
3. Attach one end of the rope to the bottle and the other end to the middle of the pole.
4. Measure the distance of the rope from the pole to the bottle and record it on the space given (meters, m).

Do work and collect data

5. Have each person stand on a chair and hold the pole horizontally so that the bottle is suspended. Twist the pole so the rope winds around it, lifting the bottle. Time how fast each person can wind the rope to bring the bottle all the way up to the pole. Record your data (in seconds).
6. Repeat so that each student has 3 tries, and record each time.
7. Using the given mass for your bottle, calculate Force by using:

   Force (N) = mass (kg) x acceleration (m/ s^2)

   Mass, m = given (kg)

   Acceleration due to gravity, a = 9.81 m/ s^2

   Record the force on the worksheet.

8. Use the worksheet to calculate average time for each person, work, power in Watts and horsepower (remember that 1 hp = 746 watts).

Discussion Questions:

1. What is power?

2. What does it mean if one person has a higher value for power?

3. How many of you would it take to light a 60 Watt light bulb?

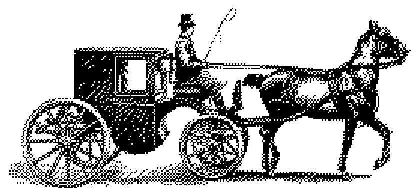
60 Watts ÷ Your Power (from the table) = _________ “your name”power

60 Watts ÷ ________Watts = _________ “________ “ power

4. How does your person power compare to the horsepower in a car (Use an estimated horsepower of 166)?

NAME : ____________________________ DATE: ___________

$W = F \times d$



$P = W / t$

PERSON	MASS, m (kg)	FORCE (N) (F=m x a) (a= 9.81m/s^2)	DISTANCE (m)	TIME (sec)	AVERAGE TIME (sec)	WORK (Joule, J) = force x distance	POWER (Watts, W) = work ÷ avg time	HORSEPOWER (hp) = Watts ÷ 746
				1.				
				2.				
				3.				
				1.				
				2.				
				3.				
				1.				
				2.				
				3.				

Homework – Energy basics

Name ________________________ Date ________________________

Remember to <u>show all work</u> including formula, answer, and units.

Suppose the Big Bad Wolf goes to the store to buy some bacon. The door at the entrance of the store says, "PULL", but The Wolf huffs and he puffs to blow the door down. The door, of course, does not move. Did The Big Bad Wolf do any work? Why or Why not? Did he use any energy?

Sylvester the Cat wants to get to Tweety Bird's cage that is hanging from the ceiling. He has to push a chair 10 meters to get it under Tweety's cage and Sylvester has to use a force of 30 Newtons to move the chair. How much work is done to move the chair to the correct spot?

If it took Sylvester 6 seconds to push the chair under the cage, what was the power involved in moving the chair?

What size light bulb uses almost the same amount of power?

Definition and Formulae

Force:

Energy:

Work:

Power:

Meter:

Kilogram:

Newton:

Joule:

Btu:

Watt:

Kilowatt:

Name ______________________   Date ______________________

Remember to <u>show all work</u> including formula, answer, and units.



Suppose the Big Bad Wolf goes to the store to buy some bacon. The door at the entrance of the store says, “PULL”, but The Wolf huffs and he puffs to blow the door down. The door, of course, does not move. Did The Big Bad Wolf do any work? Why or Why not? Did he use any energy?

The Wolf did NOT do any work because the door did not move. In order to do work, the exerted force has to move an object.

The Wolf DID use energy because he pushed on the door.

Sylvester the Cat wants to get to Tweety Bird’s cage that is hanging from the ceiling. He has to push a chair 10 ft to get it under Tweety’s cage and Sylvester has to use a force of 30 Newtons to move the chair. How much work is done to move the chair to the correct spot?

1ft = 0.3048 meters
(10 ft) x (0.3048m / 1ft) = 3.048m

W = F x D   W = (30 N) x (3.048m)   W = 91.44 Joules

If it took Sylvester 6 seconds to push the chair under the cage, what was the power involved in moving the chair?

P = W / t   P = (91.44J) / (6s)   P = 15.24 Watts

What size light bulb uses almost the same amount of power?

15 watt fluorescent / incandescent light bulb

<u>Definitions and Formulas</u>

Force:
=mass x acceleration.

Energy: the ability to do work.

potential (gravitational): mass x gravity x height

kinetic: (1/2) x mass x velocity x velocity

Work: A measure of the change of energy when a force causes an object to move.

= force x distance

Power: The work done over a given time.

= work / time

Meter: the SI (Standard International) unit for distance.

Kilogram: the SI unit for mass.

Newton: the SI unit for force. The same as a kilogram x meter / (second x second)

Joule: the SI unit for energy and work. The same as a Newton x meter

Btu: 1055 Joules. The amount of energy needed to raise 1 lb of water 1 degree Fahrenheit.

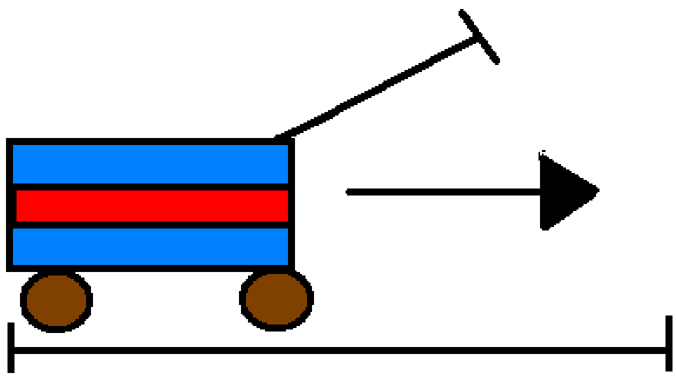
Watt: the SI unit for power. The same as a Joule/second

Kilowatt: 1000 watts

Energy Basics Assessment

Name: ________________________

You have 20 minutes to complete all of the questions. Questions 1-4 all correspond to the diagram below. Questions 5-9 are separate and must be answered within the allotted time.



1. **Write the equation for WORK.**

2. **If it takes *5 newtons* of force to move the wagon *5 meters*, how much work is being done? Remember to use the correct units.**

3. **What are the units for POWER?**

4. **If it took *10 seconds* to move the wagon, how much power was provided?**

5. What is the definition of ENERGY?

6. What S.I. unit do we use for MASS?

7. A BTU is used to describe what type of measurement?

8. FORCE is measured using (please circle the correct answer)
   a. Newtons
   b. Joules
   c. Kilograms

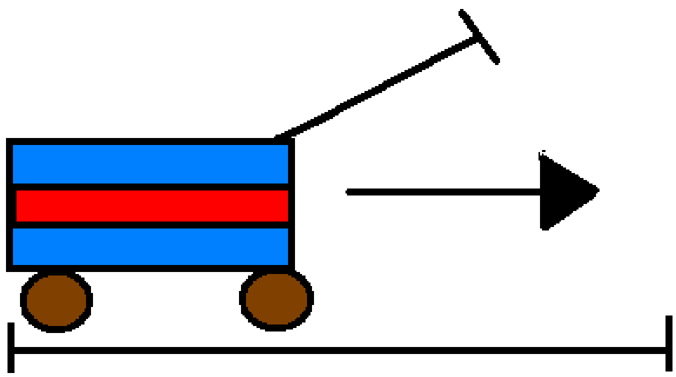
9. List three choices you can make to reduce the amount of energy you use in your life.

10. Explain why it is important to think about how much energy you use in your life.

Energy Basics - Solutions

Name: ________________________

You have 20 minutes to complete all of the questions. Questions 1-4 all correspond to the diagram below. Questions 5-8 are separate and must be answered within the allotted time.



1. **Write the equation for WORK.**

   Work = Force x distance

2. **If it takes *5 newtons* of force to move the wagon *5 meters*, how much work is being done? Remember the correct units.**

   Work = 5 newtons x 5 meters = 25 joules

3. **What are the units for POWER?**

   Watts, Kilowatts

4. **If it took *10 seconds* to move the wagon, how much power was provided?**

   Power = Work/time = 25 joules/10 seconds = 2.5 Watts

5. What is the definition of ENERGY?

The ability to do work

6. What Si unit do we use for MASS?

Kilograms

7. A Btu is used to describe what type of measurement?

Another form of Energy Units –British Thermal Units

8. FORCE is measured using (please circle the correct answer)

a. Newtons
b. Joules
c. Kilograms

9. List three choices you can do to reduce the amount of energy you use in your life.

Turn of lights, buy energy efficient appliances, buy CFLs instead of incandescent, etc…

10. Explain why it is important to think about how much energy you use in your life.

The depletion of oil, environmental, societal, and economical impacts.