Name_____

# PRE-TEST

**Directions: Circle the letter indicating whether the following statements are either true ("T") or false ("F").**

T F 1. The transfer of energy from one object or system to another involving a force is work.

T F 2. Heat is the transfer of energy from one object or system to another due to a temperature difference.

T F 3. On a graph, the responding, or dependent, variable is usually plotted on the horizontal axis.

T F 4. The unit of work is the joule.

T F 5. The unit of power is the volt.

T F 6. An air conditioner consumes 49 MJ of energy in eight hours. That is 4900 kJ.

T F 7. SI is the International System of Units used by scientists.

T F 8. The weight of an object, in newtons, can be calculated by multiplying its mass, in kilograms, by the acceleration due to gravity, in $m/s^2$.

T F 9. Solar power is a practical alternative to provide electrical energy on a small scale.

T F 10. An electric power plant can be compared to the chloroplasts of plant cells. They both convert energy into a useful form.

 Name_____

# GLOSSARY

Derived unit – a unit defined in terms of fundamental units, e.g., newton

Fundamental unit (base unit) – a unit defined in terms of an arbitrary standard, e.g., kilogram

Kilowatt-hour – a unit used to measure the amount of electrical energy used by a device or household

Power – the rate at which energy is converted; calculated by dividing energy by time; it is measured in watts

Work – the transfer of energy from one object or system to another when a force is applied over a distance


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# WHAT'S WATT?

A cyclist travelling between Jasper and Banff will have to travel up Sunwapta Pass. When travelling up this summit, many cyclists get off and push. When travelling down, they may reach 60 km / h. How can we compare the rates at which energy is converted?

The rate at which energy is converted is called power. When pushing the bicycle up the mountain, chemical potential energy of the cyclist is slowly being converted to gravitational potential energy. The power developed is small. On the trip down, gravitational potential energy is converted to kinetic energy very quickly – the power developed is great.

**Unit Analysis**

Power is measured in Watts (W). It is a derived unit, meaning it comes from fundamental units. We can express the watt in terms of those fundamental units by substituting into the power equation.

$$\text{Power} = \frac{\text{Energy}}{\text{time}}$$

$$\text{watt} = \frac{\text{joule}}{\text{second}}$$

$$\text{W} = \frac{\text{J}}{\text{s}}$$

So one watt is equivalent to one joule of energy being converted every second.

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

1. Label each of these units as fundamental or derived:

   a. meter

   b. joule

   c. kilogram

   d. newton

2. Express the joule in fundamental units. (Start with the gravitational potential energy equation and substitute in units.)


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# POWER

To calculate the power of a system we must know the energy converted and the time taken.

**Example**

Laureen lifts five 20 kg bags of grain to a height of 0.96 m in 30 s. What is Laureen's average power output?

given: $m = 20$ kg
$h = 0.96$ m
$t = 30$ s

solution:

- Find the increase in energy of one bag of grain.

  $E_p = mgh$
  $E_p = (20\text{ kg})(9.81\text{ m/s}^2)(0.96\text{ m})$
  $E_p = 188.4\text{ J/bag}$

  Note: Review the Significant Digit Rules in the Data Booklet.

- Find the energy increase for five bags

  $E_p = 5\ 3 \times 188.4 \frac{\text{J}}{2}$
  $E_p = 941.8\text{ J}$

- Find the power

  $P = \frac{E}{t}$

  $P = \frac{941.8\text{ J}}{30\text{ s}}$

  $P = 31.39\text{ W}$

  $P = 31\text{ W}$

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

3. Find your average power using this procedure:
   - measure the height of a set of stairs
   - measure your mass
   - measure the time it takes you to travel to the top of the stairs at walking speed
   - calculate your gain in gravitational potential energy $E_p = mgh$
   - calculate your power $P = \frac{E}{t}$

4. How much electric energy is used by an 800 W toaster while it operates for 90 seconds?

5. A calculator has a power rating of 0.070 mW (milliwatts). The battery lasts for a total of 85 h; how much energy is converted during this time?

Name_____

# PIZZA POWER

During this segment students cook pizza in a conventional oven and a microwave oven. The energy required in each case is calculated from the power and time data that is collected. Prepare for this segment by writing the problem that is being investigated.

*Which uses more energy to cook a quantity of food – a microwave oven or aconventional oven?*

If we know the power rating of a device and the length of time it operates we can calculate the energy it has consumed.

Example

The microwave had a power rating of 1.1 kW and operated for 6.0 min. What electric energy was consumed in this time?

given: $P$ = 1.1 kW or P = 1.1 x $10^3$ W

$t$ = 6.0 min or t = (6.0 M ) (60 $\frac{\text{s}}{\text{M}}$) = 360 s

solution: $P = \frac{E}{t}$ multiply both sides by $t$, and rearrange

$E = Pt$

$E = (1.1 \times 10^3 \text{ W})(360 \text{ s})$

$E = (1.1 \times 10^3 \frac{\text{J}}{6})(360\ 6)$

$E = 3.96 \times 10^5 \text{ J}$

$E = 0.40 \text{ MJ}$

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

6. Follow the procedure given below to answer this question:

How much electric energy is used for lighting in your household?

**Procedure**

1. Record the power rating of each bulb in your house. (The power consumption is printed on the top surface of the bulb; careful – any bulb that has been on recently can be very hot.)

2. Write the power rating on an index card and tape it to the switch which operates the light.

3. Ask your family members to record the time whenever they turn the light on or off.

4. After a day or two collect all of the cards.

**Analysis**

a. Determine the number of seconds each bulb was on.

b. Determine the energy used by each bulb using E = Pt.

c. Determine the total energy used for lighting per day in joules.

d. Determine the energy that would have been used if all bulbs were replaced with 15 W fluorescent bulbs.

e. Approximately what percent of the total energy used for lighting could be saved by using fluorescent bulbs?

Name_____

# MEGA POWER

What is the difference between a joule and a watt?

*A joule is a measure of energy; a watt measures the rate at which energy is converted. One watt is equivalent to one joule converted per second.*

The joule is a very small quantity of energy compared to the amount we consume in our homes. It is so small that we generally measure electric energy use in terms of kilowatt-hours. Both joules and kilowatt-hours measure an amount of energy.

How many joules are there in a kilowatt-hour?

$$1.0\ \text{kW}\cdot\text{h} = (1.0\ \text{kW})(1.0\ \text{h})$$

$$= (1000\ \frac{\text{J}}{\text{s}})(1.0\ 5)(60\ \frac{\text{M}}{5})(60\ \frac{\text{s}}{\text{M}})$$

$$= (1000\ \frac{\text{J}}{6})(3600\ 6)$$

$$1.0\ \text{kW}\cdot\text{h} = 3.6 \times 10^6\ \text{J} = 3.6\ \text{MJ}$$

A kilowatt-hour is equivalent to 3.6 million joules, or 3.6 megajoules of energy.

## Energy-Time Graphs

An energy versus time graph can help us to see the rate at which energy is being converted by a device or process. We call the rate of energy use power, so these graphs help us find the power rating.

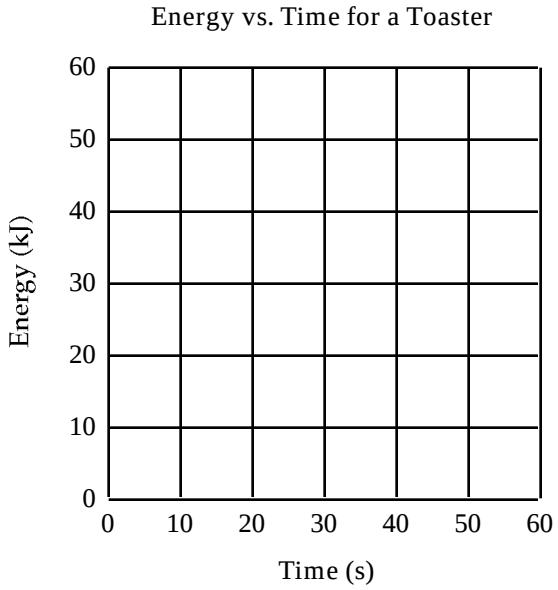
The slope is calculated from the change in vertical position (rise) divided by the change in horizontal position (run), or:

$$\text{slope} = \frac{\text{rise}}{\text{run}}$$

$$\text{slope} = \frac{\Delta E}{\Delta t}$$

To find slope of the line we choose two points on the line and substitute into the slope formula. Two convenient points on this line are:

point 1 at 20 s and 16 kJ, and
point 2 at 50 s and 40 kJ



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# MEGA POWER

Substituting in we have:

$$\text{slope} = \frac{\Delta E}{\Delta t} = \frac{E_2 - E_1}{t_2 - t_1}$$

$$= \frac{40\text{ kJ} - 16\text{ kJ}}{50\text{ s} - 20\text{ s}}$$

$$= \frac{24\text{ kJ}}{30\text{ s}}$$

$$= 0.80\frac{\text{kJ}}{\text{s}}$$

$$= 0.80\text{ kW}$$

The slope of the best-fit line on an energy versus time graph is measured in units of joules per second, but these are units of power. So the slope of the line is the power rating of the device. This toaster has a power rating of 0.80 kW, or 800 watts.

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

7. You likely pay about 7.0 cents for every kilowatt-hour of electric energy you use. How much do you pay for a joule of energy?

8. An average household uses 800 kW·h of electric energy each month. How many joules of energy would a household use in one year?

9. Plot the energy and time data for a hair dryer that is shown below. Determine the power rating of the hair dryer using the slope of the best-fit line.

Energy Consumption of a Hair Dryer

| Time (s) | Energy (kJ) |
|---|---|
| 0 | 0 |
| 15 | 18 |
| 30 | 36 |
| 45 | 54 |
| 60 | 72 |
| 75 | 90 |

Name_____

# SOLAR POWER

The Alberta Sustainable Home shown in this segment uses many features designed to capture and use solar energy for air and water heating. They have helped the Sustainable Home reduce its energy consumption greatly. In addition to being energy efficient, this home has also reduced its use of the local water supply. Captured rain water is treated and used in the home for cooking and cleaning. After being used in showers and sinks, "gray" water is used to water the lawn.

Energy Efficiency Features:

- high levels of insulation
- many south-facing windows to collect sunlight
- concrete pad is used to store thermal energy
- photovoltaic (solar) cells generate electricity
- heat transfer technology collects thermal energy from waste water
- warm air that collects near the ceiling is circulated back to the concrete pad

Results:

- generates 5000 kW·h of electricity annually
- uses 10 000 kW·h of electricity less every year than a typical home
- uses no natural gas

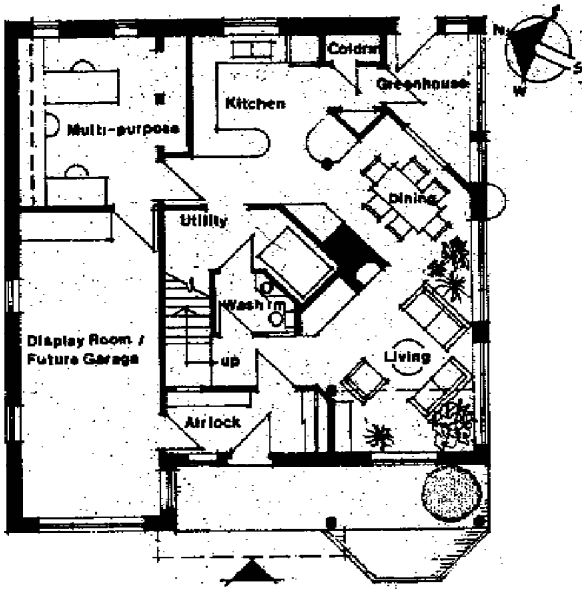
Drawbacks:

The sustainable home is not perfectly environmentally friendly because

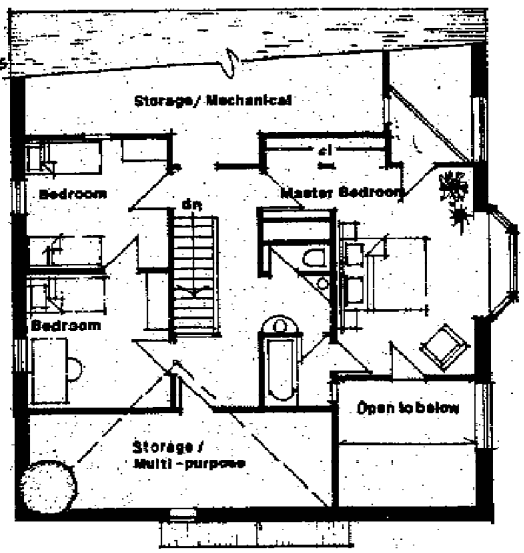
- wood is burned for heating;
- building solar panels produces chemical wastes;
- the home was more expensive to build than conventional homes of a similar size.

The Floor Plan of the Alberta Sustainable Home

main level




upper level




Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

10. Review the floor plan of the Sustainable Home and compare the number of windows on the south wall compared to the north wall. Explain the difference.

11. Identify two other features of the home that help improve its energy efficiency.

12. How does the concrete floor pad improve the energy efficiency of the home?

13. Draw the floor plan of your home, including windows. Decide how well your home is designed to gather and use solar energy.



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# POST-TEST

**Multiple Choice**

**Directions: Decide which of the choices best completes the statement or answers the question, then circle the letter that corresponds to your choice. (3 marks each)**

1. The unit of power is named after

   a. James Joule
   b. James Watt
   c. Alessandro Volta
   d. André Marie Ampère

2. The rate of doing work defines

   a. heat
   b. work
   c. power
   d. energy

3. A toaster takes 45.0 seconds to toast two slices of bread and consumes 67.5 kJ of electrical energy. Its power rating is

   a. 1.5 W
   b. 67.5 W
   c. 1500 W
   d. 3038 W

**LONG ANSWER**

**Directions: Answer the following questions in the spaces provided. Use the back of the sheet if necessary.**

1. A joule per second is equal to _____. (3 marks)

2. To calculate power we use the formula _____. (3 marks)

3. The slope of an energy versus time graph is equal to _____. (3 marks)

4. A compact stereo set has a power consumption rating of 35 W. Calculate the electrical energy consumed in a two hour period of continuous use. (8 marks)

 Name_____

# POST-TEST

5. A science student walks up a flight of stairs in 20.0 s. The student's mass is 54.0 kg and the height of the stairs is 2.00 m. Calculate the power developed by the student in climbing the stairs. (10 marks)

6. One horsepower is equal to _____ watts. (3 marks)

7. The kilowatt·hour is a unit of _____. (3 marks)

8. During a two-hour peak demand period a power plant delivers 225 MW of power to its consumers. Calculate the energy consumption during that time. (8 marks)

9. Why are compact fluorescent bulbs recommended, in place of incandescent bulbs, for home lighting? (6 marks)

10. A microwave oven has a consumption rating of 1100 W and delivers 700 J/s to food being cooked. Determine the efficiency of this particular oven. (8 marks)

Name_____

# POST-TEST

11. Your electric power bill shows a consumption of 1041 kW·h for which you pay $77.86. What is the cost per kilowatt·hour? (8 marks)

12. Using the rate calculated in question 11., how much does it cost to operate a stereo with a 35 W consumption rating for 1.5 h? (10 marks)

13. A laser pointer consumes 4.0 mW and is powered by a dry cell with 250 J of available potential energy. How many hours can the pointer be operated with this dry cell? (8 marks)


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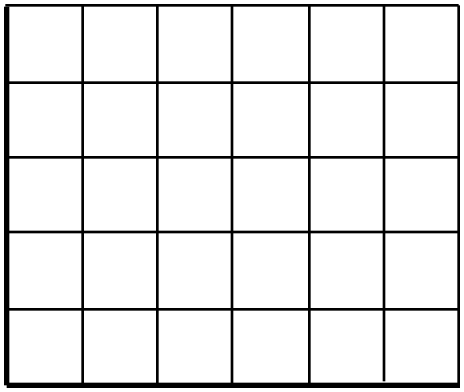
# POST-TEST

14. The following data shows the electrical energy delivered by a wind turbine. Plot the data on the grid provide and use the graph to calculate the power developed. (10 marks)

| Time (s) | Energy (kJ) |
|---|---|
| 0 | 0 |
| 5 | 12 |
| 10 | 24 |
| 15 | 36 |
| 20 | 48 |
| 25 | 60 |
| 30 | 72 |

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