Name: _____ Date: _____ Skill and Practice

7H Efficiency

Read:

In a perfect machine, the work input would equal the work output. However, there aren't any perfect machines in our everyday world. Bicycles, washing machines, and even pencil sharpeners lose some input work to friction. *Efficiency* is the ratio of work output to work input. It is expressed as a percent. A perfect machine would have an efficiency of 100 percent.

Example:

An engineer designs a new can opener. For every twenty joules of work input, the can opener produces ten joules of work output. The engineer tries different designs and finds that her improved version produces thirteen joules of work output for the same amount of work input. How much more efficient is the new version?

Efficiency of the first design

$$\text{Efficiency} = \frac{\text{work output}}{\text{work input}}$$
$$= \frac{10 \text{ joules}}{20 \text{ joules}}$$
$$= 50\%$$

Efficiency of the second design

$$\text{Efficiency} = \frac{\text{work output}}{\text{work input}}$$
$$= \frac{13 \text{ joules}}{20 \text{ joules}}$$
$$= 65\%$$

The second design is 15% more efficient than the first.

Practice:

1. A cell phone charger uses 4.83 joules per second when plugged into an outlet, but only 1.31 joules per second actually goes into the cell phone battery. The remaining joules are lost as heat. That's why the battery feels warm after it has been charging for a while. How efficient is the charger?

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2. A professional cyclist rides a bicycle that is 92 percent efficient. For every 100 joules of energy he exerts as input work on the pedals, how many joules of output work are used to move the bicycle?

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3. An automobile engine is 15 percent efficient. How many joules of input work are required to produce 15,000 joules of output work to move the car?

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Skill and Practice

4. It takes 56.5 kilojoules of energy to raise the temperature of 150 milliliters of water from 5 °C to 95 °C. If you use an electric water heater that is 60% efficient, how many kilojoules of electrical energy will the heater actually use by the time the water reaches its final temperature?

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5. A power station burns 75 kilograms of coal per second. Each kg of coal contains 27 million joules of energy.

   a. What is the total power of this power station in watts? (watts = joules/second)

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   b. The power station's output is 800 million watts. How efficient is this power station?

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6. A machine requires 2,000 joules to raise a 20 kilogram block a distance of 6.0 meters. How efficient is the machine? (Hint: Work done against gravity = mass × acceleration due to gravity × height.)
