Where Energy Goes

Investigate what efficiency numbers reveal about everyday machines.

PHY.3.10 "Enrichment: Research the efficiency of everyday machines (e.g., automobiles, hair dryers, refrigerators, and washing machines)."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each machine's energy input and useful output. Circle any detail that affects whether two efficiency numbers can be compared fairly.

The Numbers Behind the Machines

1. At a car dealership, a bold fuel-economy number may catch your eye. In physics, energy efficiency compares useful energy output with energy input: divide output by input and multiply by 100 to get a percentage. What counts as useful depends on the machine's job and where you draw the system boundary. Imagine a car that receives 100 megajoules of chemical energy from fuel during a trip and delivers 25 megajoules of mechanical energy at its wheels. The rest leaves mainly as heat through the engine, exhaust, and friction. These figures describe energy conversion, not miles traveled per gallon.

2. Now consider a hair dryer. Its electrical input is 1.0 kilowatt-hour, while 0.90 kilowatt-hour becomes heat in the outgoing air. This counts heated airflow as useful output, although some warm air misses the hair. A refrigerator does something different: it uses electricity to move heat from its cold interior into the kitchen. Suppose it uses 0.20 kilowatt-hour of electricity while removing 0.60 kilowatt-hour of heat. Researchers report heat moved divided by electricity used as a coefficient of performance, or COP. COP is not an energy-conversion efficiency percentage because the refrigerator moves existing heat rather than creating that heat from electricity.

3. Researching real machines takes more than finding one impressive number. An EnergyGuide label estimates a refrigerator's annual electricity use under standardized test conditions, which may differ from a family's use. One 18-cubic-foot model lists 360 kilowatt-hours per year; a 12-cubic-foot model lists 330 kilowatt-hours per year. The smaller total does not prove the second model does the same job with less energy: it has less storage space. To investigate washing machines, compare energy use per load at similar load sizes and wash settings, and check whether both loads meet the same cleaning goal. Record each figure's source and test conditions.

2 ANSWER WITH EVIDENCE

Use the passage

1. Using the passage's definition, what is the car's energy-conversion efficiency? Show your calculation.

2. What is the hair dryer's efficiency when heated airflow counts as useful output? Why might this number overstate how much energy helps dry hair?

3. Calculate the refrigerator's COP from the passage. Why should you not report that result as an energy-conversion efficiency percentage?

4. Can you conclude that the refrigerator using 330 kilowatt-hours per year is more efficient than the one using 360? Explain what makes this comparison uncertain.

3 YOUR TURN

Your own words

Choose an everyday machine not named in the passage. Write a plan to compare the energy efficiency of two models. Identify the useful output, the input and output data you would collect, how you would obtain them, and one condition you would keep the same.

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PART 1 · READ AND MARK

Underline each machine's energy input and useful output. Circle any detail that affects whether two efficiency numbers can be compared fairly. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Using the passage's definition, what is the car's energy-conversion efficiency? Show your calculation.	**25 megajoules ÷ 100 megajoules × 100 = 25%.**
2	What is the hair dryer's efficiency when heated airflow counts as useful output? Why might this number overstate how much energy helps dry hair?	**0.90 ÷ 1.0 × 100 = 90%. Some heated air misses the hair.**
3	Calculate the refrigerator's COP from the passage. Why should you not report that result as an energy-conversion efficiency percentage?	**0.60 ÷ 0.20 = 3. The refrigerator moves existing heat; it does not convert electricity into all of that heat.**
4	Can you conclude that the refrigerator using 330 kilowatt-hours per year is more efficient than the one using 360? Explain what makes this comparison uncertain.	**No. The 330-kilowatt-hour model has less storage space, so the two models do not provide the same amount of storage.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would compare two electric kettles heating 0.5 liter of water from 20°C to 90°C. I would use a plug-in energy meter to measure each kettle's electrical input, then measure the water's temperature change to calculate its useful heat gain. I would use the same amount of water at the same starting temperature in both kettles. For each model, I would divide the heat gained by the water by its electrical input and compare the results.

Accept equivalent calculations and explanations. For Part 3, accept plans that define a useful output, identify measurable input and output data, name a credible source or measurement method, and control a relevant condition.