LESSON MAKER PRO

Energy Design Lab

Calculate efficiency and test device designs against constraints.

HIGH SCHOOL · HS-PS3-3

HS-PS3-3 "Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices..."

NAME _____ DATE _____

MEASURING EFFICIENCY

A device's efficiency compares the useful energy it produces with the energy it takes in. Efficiency = useful output energy / input energy × 100%. Energy that does not become useful output is converted to other forms, such as heat or sound.

WORKED EXAMPLE

A fan takes in 160 J of electrical energy and gives 96 J of useful motion energy to the air. What is its efficiency?

1. Divide useful output by input: 96 / 160 = 3/5.
2. Convert to a percent: 3/5 × 100% = 60%.

Answer: 60%

PRACTICE 6 problems

1 An LED lamp takes in 200 J of electrical energy and produces 50 J of useful light energy. What is its efficiency?

ANSWER _____

2 A solar charger takes in 150 J of sunlight energy and produces 45 J of electrical energy. What is its efficiency?

ANSWER _____

3 A motor takes in 120 J of electrical energy and produces 48 J of useful motion energy. What is its efficiency?

ANSWER _____

4 A water-powered generator takes in 300 J of energy from moving water. If it is 50% efficient, how much electrical energy does it produce?

ANSWER _____

5 A motor takes in 400 J of electrical energy and produces 280 J of useful motion energy. What is its efficiency, and how much energy is converted to other forms?

ANSWER _____

6 A wind turbine takes in 500 J of wind energy and produces 225 J of electrical energy. A design must be at least 40% efficient. What is the turbine's efficiency, and does it meet the constraint?

ANSWER _____

APPLY IT Show your work

1 You are choosing a solar charger for a phone at an outdoor event. In one test, it takes in 600 J of sunlight energy and delivers 210 J of electrical energy. To qualify, it must be at least 30% efficient and deliver at least 200 J. Does it meet both constraints? Calculate its efficiency.

WORK SPACE

ANSWER _____

2 Your school is testing two bike-powered speaker designs for a dance. Each takes in 900 J of energy from pedaling. A design must produce at least 400 J of electrical energy and be at least 40% efficient. Use the table to find each design's efficiency. Which design meets both constraints?

BIKE-POWERED SPEAKER TESTS

Design	Useful electrical energy
A	360 J
B	450 J

ANSWER _____

CHALLENGE One step up

A student is refining a solar charging device. It takes in 700 J of sunlight energy and currently produces 350 J of useful electrical energy. Each refinement adds 35 J to the useful output without changing the input. The device must produce at least 490 J. What is the fewest refinements needed, and what will its efficiency be then? Show your reasoning.

WORK SPACE AND ANSWER

Energy Design Lab

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	An LED lamp takes in 200 J of electrical energy and produces 50 J of useful light energy. What is its efficiency?	**25%**
2	A solar charger takes in 150 J of sunlight energy and produces 45 J of electrical energy. What is its efficiency?	**30%**
3	A motor takes in 120 J of electrical energy and produces 48 J of useful motion energy. What is its efficiency?	**40%**
4	A water-powered generator takes in 300 J of energy from moving water. If it is 50% efficient, how much electrical energy does it produce?	**150 J**
5	A motor takes in 400 J of electrical energy and produces 280 J of useful motion energy. What is its efficiency, and how much energy is converted to other forms?	**70% efficient; 120 J converted to other forms**
6	A wind turbine takes in 500 J of wind energy and produces 225 J of electrical energy. A design must be at least 40% efficient. What is the turbine's efficiency, and does it meet the constraint?	**45%; yes, it meets the constraint**

PART 2 · APPLY IT

1. **Yes. Its efficiency is 35%, and it delivers 210 J, so it meets both constraints.** 210 / 600 × 100% = 35%. Both 35% and 210 J meet the stated minimums.
2. **A is 40% efficient, and B is 50% efficient. Only B meets both constraints.** 360 / 900 × 100% = 40%, and 450 / 900 × 100% = 50%. A produces less than the required 400 J, while B meets both minimums.

CHALLENGE

Four refinements. The device needs 490 J - 350 J = 140 J more useful output, and 140 / 35 = 4. Its efficiency will be 490 / 700 × 100% = 70%.

Accept equivalent calculations and wording. For the constraint problems, students must check every stated minimum, not efficiency alone.