

Work, energy and power

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

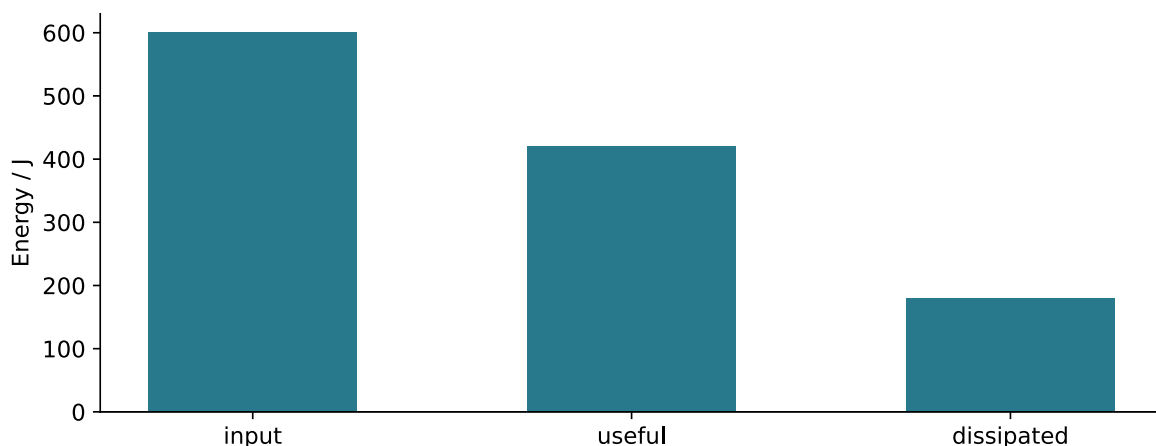
Energy stores, work and efficiency

■ What would explain this observation?

- A motor can transfer some input energy to lifting and the rest to heating. Useful output is part of the total energy transfer.

■ Build the model

- Work done by a constant force parallel to displacement is force multiplied by distance.
- Kinetic energy depends on speed squared.
- Energy is conserved when all transfers and stores are included.
- **power** : Energy transferred per unit time.
- **efficiency**: Useful output divided by total input.



Efficiency = useful $\div$ input = $420 \div 600 = 70\%$; the other 180 J is dissipated

■ Choose evidence that can test it

- Define the system and useful output before calculating efficiency.
- Doubling speed quadruples kinetic energy at constant mass.
- Power describes transfer per time, not total energy.

In the lab: Measure a lifting height and load, time the lift, and record electrical input with suitable instruments. Repeat trials and account for heating or friction as transfers, not missing energy.

■ Work from known quantities

- Known: a device receives 600 J and transfers 420 J usefully.
- Efficiency = useful output / total input.
- Efficiency = $420/600 = 0.70 = 70\%$.
- Over 3 s, useful power = useful energy/time = $420/3 = 140$ W.

Your turn: A device receives 250 J and gives 150 J useful output. Find efficiency as a percentage.

■ Check the conclusion and its limits

- Efficiency cannot exceed 100% for a properly defined energy balance.
- Energy dissipated by heating is still conserved.

Not true: Dissipated energy is destroyed. Energy is always conserved. “Dissipated” means spread into the surroundings as heating, where it becomes hard to use again - not destroyed.

Key:

- Work done by a constant force parallel to displacement is force multiplied by distance.
- Define the system and useful output before calculating efficiency.
- Watch for: efficiency cannot exceed 100% for a properly defined energy balance.

■ Write from an efficiency of 45 percent

- A device receives 200 J and gives 90 J of useful output.
- Find the efficiency. The other energy is dissipated, not destroyed.

■ Write from a useful output of 750 joules

- A machine takes in 1,200 J at an efficiency of 62.5 percent.
- Useful output = $0.625 \times 1,200 = 750$ J, dissipated 450 J – energy accounted, never destroyed.

■ **Write from an efficiency of 25 percent**

- A lift motor draws 4,000 J per floor and delivers 1,000 J of useful lifting.
- Efficiency = $1,000 \div 4,000 = 25$ percent, and the other 3,000 J is heated motor and cable – name where it goes.

■ **Write from a Sankey read**

- A diagram shows 100 J in: a 70 J useful arrow and a 30 J wasted arrow.
- Efficiency 70 percent – and the wasted arrow's WIDTH is the quantity: a Sankey diagram is an energy account drawn to scale.