PHYS11 CH7: Power, Energy & Human Systems

Sections 7.7-7.9: Power, Human Energy, and World Energy Use

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Learning Objectives

After this lesson, you will be able to:

- Calculate power by analyzing changes in energy over time
- Explain human body energy consumption at rest vs. during activity
- Calculate the conversion of chemical energy in food to useful work
- Describe the distinction between renewable and nonrenewable energy sources
- Explain why energy conservation is necessary despite total energy being conserved

Power: Rate of Energy Transfer

Definition

Power (P) is the rate at which work is done or energy is transferred:

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

SI unit: Watt (W) = 1 Joule/second

Key Equations

- Average Power: $P_{avg} = \frac{\Delta E}{\Delta t}$
- Instantaneous Power: $P = \frac{dE}{dt}$
- Relation to Force: $P = \vec{F} \cdot \vec{v}$

Human Energy Systems

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Human Energy Systems

Basal Metabolic Rate (BMR)

- Energy used at rest
- Typical adult: 70-100 W
- Major users:
  - Liver & Spleen (27%)
  - Brain (19%)
  - Muscles (18%)

Active Power Output

- Walking: 280 W
- Cycling: 400 W
- Sprinting: 2415 W
- Efficiency: 15-30%

World Energy Use

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World Energy Use

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World Energy Use

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Example: Calculating Power Output

Problem

A 60.0-kg person climbs stairs at a rate of 116 stairs per minute. If each stair is 0.15 m high, what is their power output?

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Solution

$$
\begin{aligned}
\text{Work per stair} &= mgh = (60.0 \text{ kg})(9.80 \text{ m/s}^2)(0.15 \text{ m}) \\
&= 88.2 \text{ J} \\
\text{Power} &= \frac{\text{Work}}{\text{time}} = \frac{88.2 \text{ J} \times 116}{60 \text{ s}} \\
&= 170 \text{ W}
\end{aligned}
$$

Practice Problem - Together

Problem

A person consumes a 250 Calorie (1047 kJ) snack. How long would they need to cycle at 400 W to burn off this energy, assuming 20% efficiency?

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Work Together

Let's solve this step by step:

1. Convert food energy to Joules
2. Account for efficiency
3. Use power equation to find time

Practice Problem - Independent

Your Turn

Calculate the power output of a wind turbine that lifts 1000 kg of water 100 m high in 5 minutes.

- Use $g = 9.80\ \text{m/s}^2$
- Calculate work done first
- Convert to power using time

Practice Problem - Independent

Your Turn

Calculate the power output of a wind turbine that lifts 1000 kg of water 100 m high in 5 minutes.

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Check

Answer: 32.7 kW

Summary

Key Takeaways

- Power is the rate of energy transfer
- Human power output varies by activity
- Body efficiency typically 15-30%
- World energy use dominated by nonrenewables
- Energy conservation crucial for sustainability

Next Steps

- Practice power calculations
- Consider personal energy usage
- Think about renewable energy solutions