SCIENCE FOUNDATIONS

Conservation of energy

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how you explain that energy never disappears, like a roller coaster trading height for speed and back again, with some energy always ending up as heat. A hydro dam turns the energy of falling water into electricity, and a phone battery slowly turns its stored energy into heat and light. Nothing creates energy from nothing, so an engineer has to account for where every bit of it goes. Knowing this tells you why a machine can never give back more energy than you put into it.



Rule

Conservation of energy: energy cannot be created or destroyed, it can only change form.

In a closed system (one where no energy comes in or goes out) the total energy stays the same, so the energy at the start equals the energy at the end.

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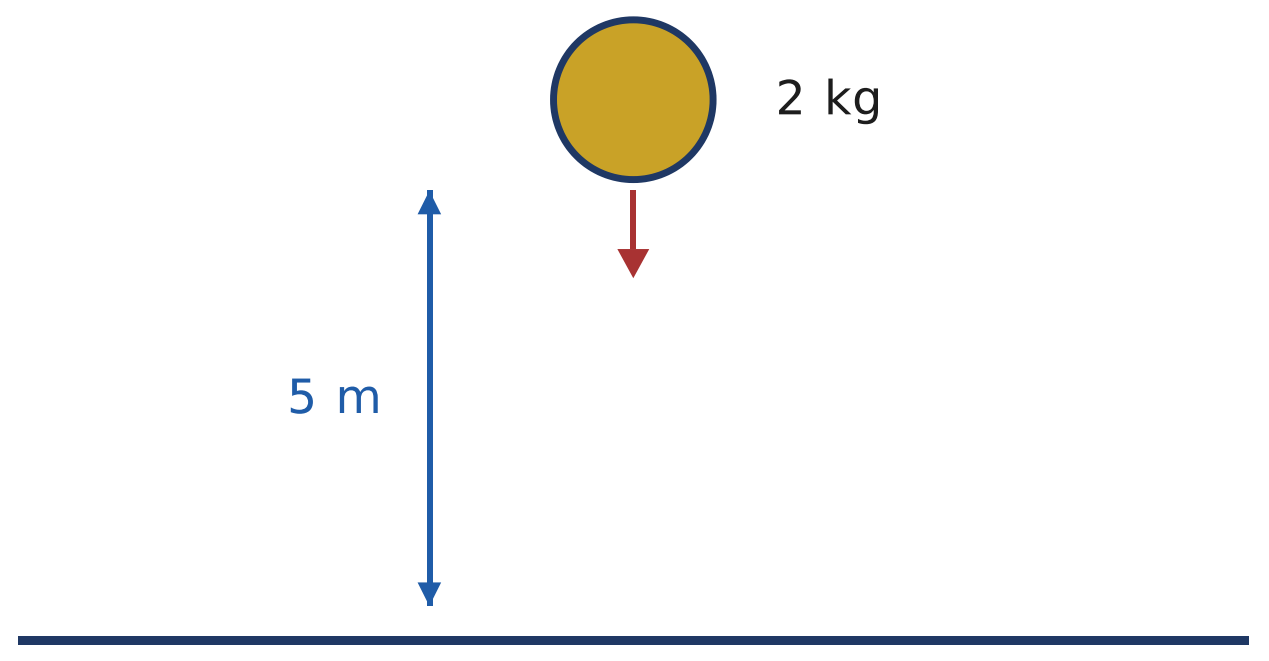
Worked examples

EXAMPLE 1

Q A 2 kg ball drops from 5 m. Speed at the ground (ignore air, g 9.8)?



SOLUTION

Start energy: potential only, mass times g times height:

$2 \times 9.8 \times 5 = 98$ J

End energy: kinetic only, one half of mass times v^2:

$\frac{1}{2} \times 2 \times v^2$. One half of 2 is 1, so this is just v^2.

Set equal:

$v^2 = 98$

$v = \sqrt{98} = 9.9$ m/s

The result is speed about 9.9 m/s.

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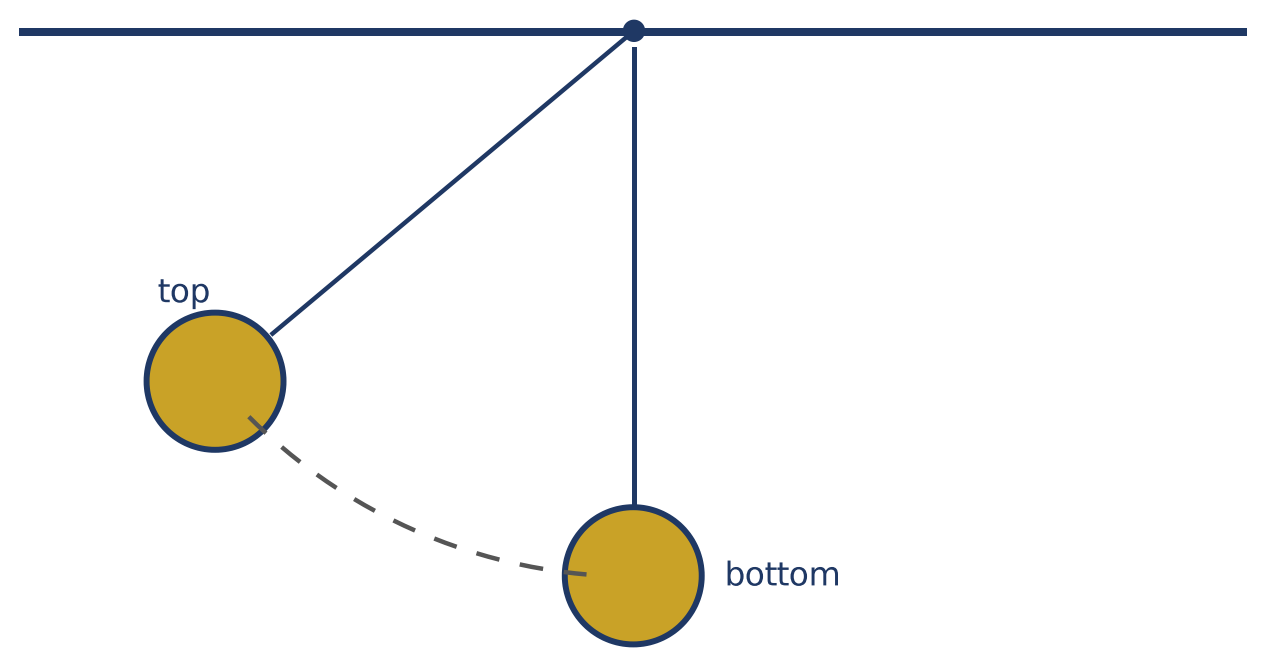
EXAMPLE 2

Q A pendulum swings: what happens to energy at the top and bottom?



SOLUTION

At the top: height is greatest, so potential energy is greatest, speed is zero.

At the bottom: height is lowest, so kinetic energy is greatest.

Total stays the same throughout the swing.

The result is potential greatest at top, kinetic greatest at bottom.

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Practice questions

1. A 5 kg ball drops from 20 m. What is its speed at the ground? Ignore air resistance and use $g = 9.8\ m/s^2$

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2. A 1 kg ball drops from 10 m. How much gravitational potential energy does it lose by the time it reaches the ground? Use $g = 9.8\ m/s^2$.

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3. A 4 kg ball is moving at 5 m/s. What is its kinetic energy?

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4 A pendulum swings from side to side. At which point is it moving fastest?

- **A** At the bottom of the swing
- **B** At the top of the swing
- **C** Halfway up on each side
- **D** It moves at the same speed everywhere

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5 A child on a swing is at the highest point. Which energy is greatest there, and which is greatest at the lowest point?

- **A** Potential at the top, kinetic at the bottom
- **B** Kinetic at the top, potential at the bottom
- **C** Potential at both points
- **D** Kinetic at both points

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Conservation of energy in one line?

A Total energy stays constant

B Total energy grows over time

C Total energy shrinks over time

D Energy appears from nowhere

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Does total energy change in a closed system?

A Yes

B No

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Where does friction energy go?

A Heat

B Light

C Sound

D Electricity

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A ball at rest at height: which energy does it have?

A Potential

B Kinetic

C Heat

D Chemical

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Which of these is an example of energy changing from kinetic to potential?

A. A ball rolling up a hill and slowing down

B. A ball falling and speeding up

C. A car cruising at a steady speed

D. A book sitting on a shelf

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ANSWER KEY

1. 19.8 m/s

2. 98 J

3. 50 J

4. At the bottom of the swing

5. Potential at the top, kinetic at the bottom

6. Total energy stays constant

7. No

8. Heat

9. Potential

10. A ball rolling up a hill and slowing down

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