

Energy conservation, bar charts and power

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to track energy between kinetic, gravitational, spring and thermal stores, to read energy bar charts and graphs, and to calculate power in everyday machines. They follow the style of AP Physics 1 unit 3.

Start with the short recall and one-step problems, then move to multi-step and design-style problems. Use $g = 9.81 \text{ m/s}^2$ and show every substitution with units.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 3

Problem 1 Name the energy store (easy)

Name the main form of energy stored in each system.

1. A stretched elastic band.
2. A cricket ball at the top of its flight.
3. A fast-moving motorbike.
4. A parked lorry on a hilltop.
5. Explain in one sentence why a ball resting on the floor still has gravitational potential energy if the reference level is a basement floor.

Problem 2 Lifting a water container (easy)

Wanjiru in Nairobi lifts a 12 kg container of water onto a shelf 1.5 m above the floor.

1. Calculate the gain in gravitational potential energy.
2. State what happens to this value if the reference level is moved to the shelf.

Problem 3 Energy in a spring (easy)

A spring has a constant of 400 N/m and is compressed by 0.050 m.

1. Calculate the elastic potential energy stored.
2. Calculate the energy stored if the compression is doubled, and state how it compares with your first answer.

Problem 4 Motor power (easy)

A small motor does 4500 J of work in 30 s.

1. Calculate its average power.
2. Calculate the work it would do in 2.0 minutes at this power.

Problem 5 Unit conversions (easy)

Convert each quantity.

1. 2.5 kW into watts.
2. 0.75 kWh into joules.
3. 8400 J per minute into watts.

Problem 6 Dropped cricket ball (easy)

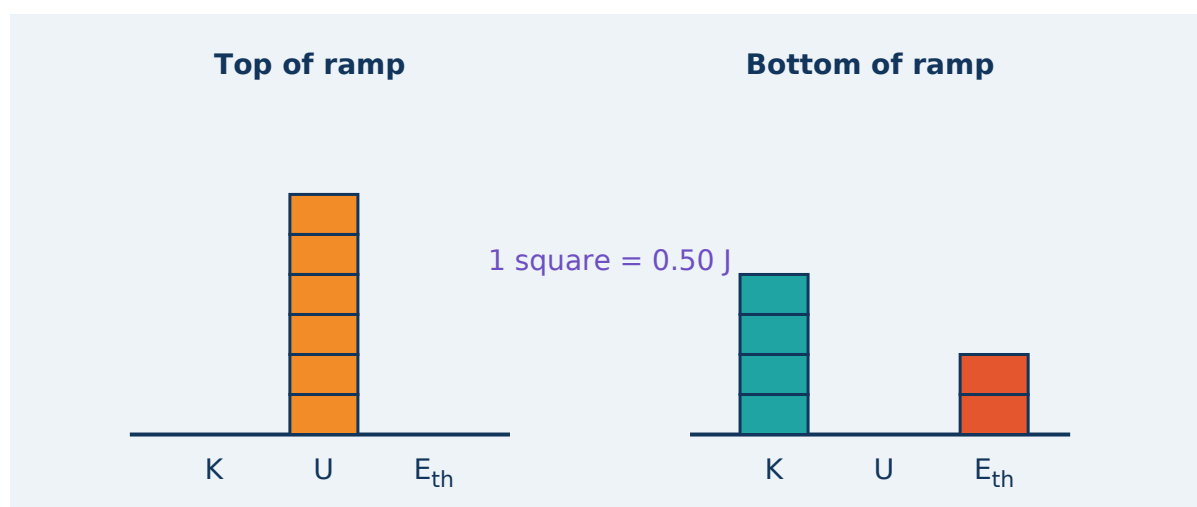
Emma in Leeds drops a 0.15 kg ball from a height of 1.8 m. Ignore air resistance.

1. Calculate the kinetic energy just before it lands.
2. Calculate its speed just before it lands.

Problem 7 Reading a bar chart (medium)

A 0.20 kg ball rolls down a ramp. The bar charts show the start and end of the motion.

1. Find the total energy at the top of the ramp.
2. Calculate the thermal energy produced.
3. Calculate the height of the top of the ramp above the bottom.
4. Calculate the ball's speed at the bottom.



Each square stands for 0.50 J. K is kinetic energy, U gravitational potential energy and E_{th} thermal energy.

Problem 8 Spring-launched ball (medium)

A 0.050 kg ball sits on a vertical spring ($k = 200 \text{ N/m}$) compressed by 0.060 m. When released, the ball is launched straight up. Ignore air resistance.

1. Calculate the energy stored in the compressed spring.
2. Calculate the maximum height of the ball above its release position.

Problem 9 Crate on a rough ramp (medium)

Mei in Singapore lets a 25 kg crate slide from rest down a ramp that is 3.0 m long and 1.2 m

high. It reaches the bottom at 2.0 m/s.

1. Calculate the loss of gravitational potential energy.
2. Calculate the final kinetic energy.
3. Calculate the thermal energy produced.
4. Calculate the average friction force.

Problem 10 Climbing power (medium)

Bilal in Lahore (65 kg) runs up a flight of stairs that rises 4.2 m in 9.0 s.

1. Calculate the energy he gains.
2. Calculate his average power output.

Problem 11 Motorbike on the highway (medium)

A motorbike cruises at a steady 20 m/s against a total resistive force of 350 N.

1. State the force the engine must supply, and explain why.
2. Calculate the power the engine delivers to the road.
3. Calculate the energy delivered in 15 minutes, in joules and in kWh.

Problem 12 Kettle energy (medium)

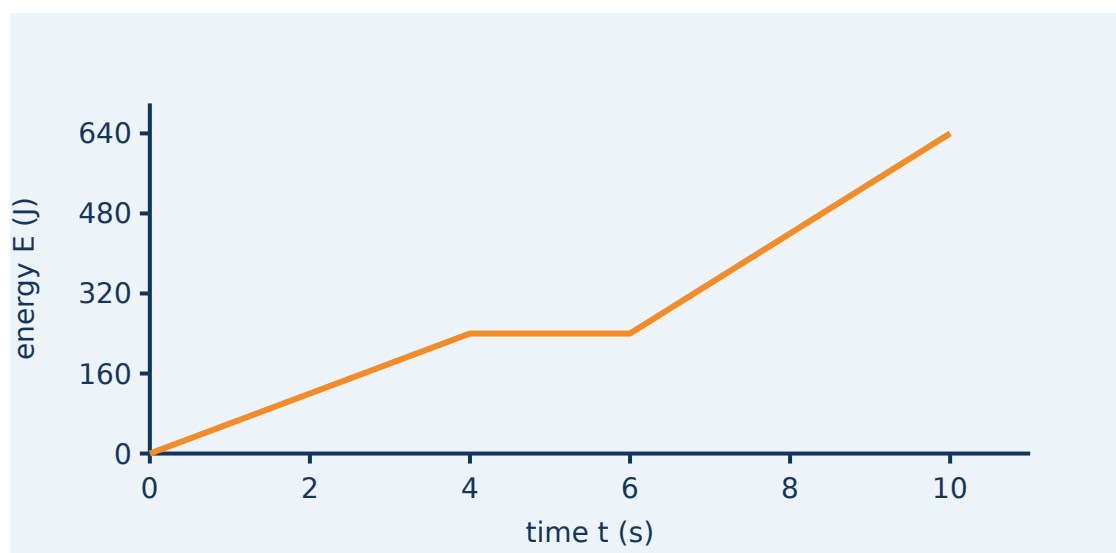
A kettle rated at 1.5 kW is switched on for 3.0 minutes.

1. Calculate the electrical energy used in joules.
2. Convert your answer to kilowatt-hours.

Problem 13 Reading an energy graph (medium)

The graph shows the energy a small motor transfers over ten seconds.

1. Calculate the power during the first 4.0 s.
2. State the power between 4.0 s and 6.0 s, and suggest what the motor is doing.
3. Calculate the power between 6.0 s and 10 s.
4. Calculate the average power over the full ten seconds.



Energy transferred by a small motor during ten seconds of operation.

Problem 14 Swinging pendulum (medium)

A 0.30 kg pendulum bob is released from rest at a point 0.20 m above its lowest position.

1. Calculate its speed at the lowest point.
2. Calculate the kinetic energy there.
3. Calculate the height above the lowest point where the speed is half of the maximum speed.

Problem 15 Minimum height for a loop (hard)

A cart is released from rest on a smooth track that leads into a vertical loop of radius $R = 3.0$ m. At the top of the loop the cart must just keep contact with the track, so the net force there is its weight alone.

1. Show that the speed at the top satisfies $v^2 = gR$.
2. Use energy conservation to calculate the minimum release height above the bottom of the loop.

Problem 16 Block and spring on rough floor (hard)

A 2.0 kg block is pressed against a spring ($k = 500$ N/m, not attached) and compressed by 0.20 m on a horizontal floor with $\mu_k = 0.30$. The block is released.

1. Calculate the energy stored in the spring.
2. Calculate the friction force on the block.
3. Calculate the total distance the block travels from its release position before stopping.

Problem 17 Uphill cycling (hard)

Kofi in Accra cycles up a straight 5.0° hill at a constant 4.0 m/s. The rider and bicycle have a combined mass of 80 kg. Ignore air resistance and rolling resistance.

1. Calculate the component of weight along the slope.
2. Calculate the mechanical power Kofi delivers.
3. His muscles are 24 % efficient. Calculate the chemical power his body must supply.

Problem 18 Pumping water from a well (hard)

A pump lifts 1500 kg of water every minute from a well 12 m deep and delivers it at 3.0 m/s at the top.

1. Calculate the mass of water lifted each second.
2. Calculate the power needed to raise the water and the power needed to give it kinetic energy.
3. The pump motor is 70 % efficient. Calculate its electrical input power.

Problem 19 Mass on a vertical spring (hard)

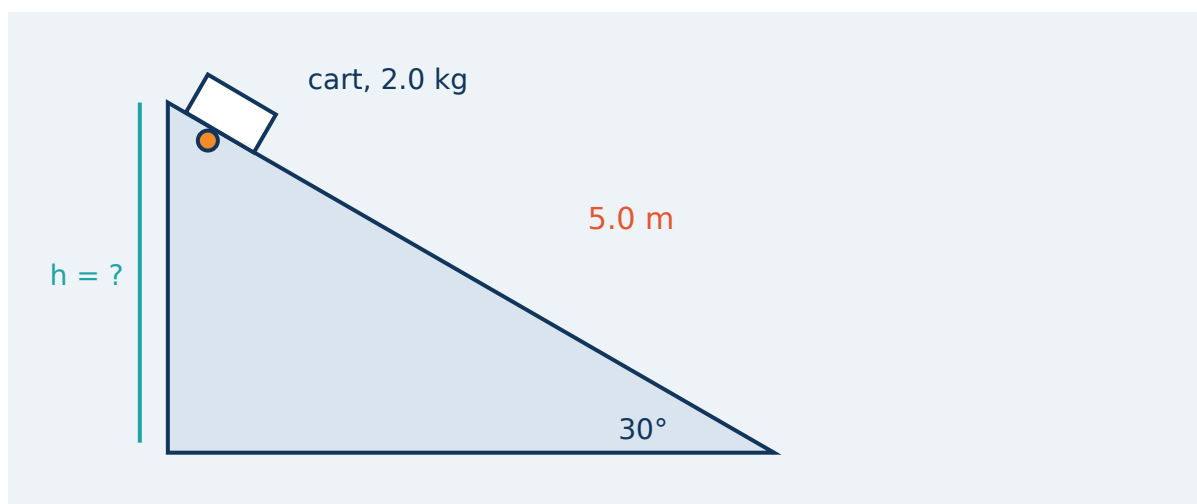
A 0.50 kg mass is attached to a vertical spring ($k = 40 \text{ N/m}$) at its relaxed length and is released from rest.

1. Use energy conservation to calculate the maximum extension of the spring.
2. Calculate the speed of the mass when the extension is half of the maximum.
3. Explain why the mass does not stay at the position where the net force is zero.

Problem 20 Spot the error (hard)

Aarav in Pune is asked for the speed of a 2.0 kg cart released from rest at the top of the smooth slope shown. He writes $mg(5.0) = \frac{1}{2}mv^2$, giving $v = 9.9 \text{ m/s}$.

1. Identify his error.
2. Calculate the correct speed.
3. State whether the answer would change for a 4.0 kg cart, and explain why.



The cart is released from rest at the top of the slope.