

Work, kinetic energy and the net-work theorem

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These twenty problems train the AP Physics 1 unit 3 skills of finding work, using kinetic energy and applying the work-energy theorem. They begin with signs, units and one-step calculations, move to force-position graphs and friction, and end with free-response tasks such as a paragraph argument and an experimental design.

Use $g = 9.81 \text{ m/s}^2$ and show each substitution. Remember that the theorem uses the net work of all the forces, and keep a sign with every work value.

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

Problem 1 Sign of the work (easy)

State whether each force does positive, negative or zero work on the object named.

1. Gravity on a falling apple.
2. Friction on a crate sliding to a stop.
3. The normal force from the floor on a person walking along it.
4. The tension in the string on a ball moving in a horizontal circle.

Problem 2 Market cart (easy)

Tolu in Ibadan pushes a market cart with a horizontal force of 120 N for 18 m.

1. Calculate the work she does.
2. How far could she push the cart with a force of 150 N if she does 4500 J?

Problem 3 Tennis serve (easy)

A tennis ball of mass 0.057 kg leaves a racket at 45 m/s.

1. Calculate its kinetic energy.
2. State the kinetic energy if the speed were 90 m/s.

Problem 4 Units of energy (easy)

Work with the unit of energy.

1. Show that $1 \text{ J} = 1 \text{ kg m}^2/\text{s}^2$.
2. Convert 2.4 kJ to joules.
3. A 1000 kg car travels at 72 km/h. Convert the speed to m/s and calculate its kinetic

energy.

Problem 5 Angle matters (easy)

A constant force of 40 N acts on a block that moves 5.0 m to the right. Calculate the work done by the force when its direction relative to the motion is:

1. 0° .
2. 60° .
3. 90° .
4. 180° .

Problem 6 From work to speed (easy)

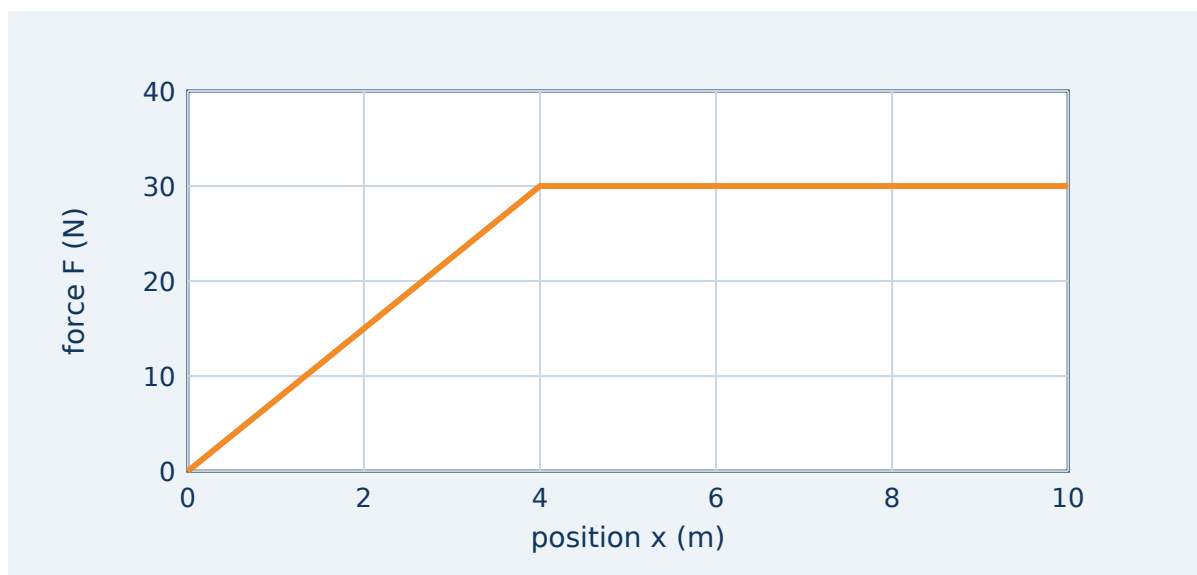
A net work of 150 J is done on a 3.0 kg cart that starts at rest.

1. State the kinetic energy gained.
2. Calculate the final speed.

Problem 7 Force along a rail (medium)

A 5.0 kg cart on a rail is pulled by a force that varies with position as shown. It starts from rest at $x = 0$. Friction is negligible.

1. Calculate the work done between 0 and 4.0 m.
2. Calculate the total work between 0 and 10 m.
3. Calculate the speed at 10 m.



Force on the cart against position.

Problem 8 Loaded trolley (medium)

Wanjiru pulls a 15 kg trolley 12 m along a level floor with a rope force of 30 N at 35° above the horizontal. Friction on the trolley is a constant 14 N. The trolley starts at rest.

1. Calculate the work done by the rope.

2. Calculate the work done by friction.
3. Calculate the final speed of the trolley.

Problem 9 Frictionless ramp (medium)

A 0.30 kg book slides from rest down a frictionless ramp 2.5 m long, inclined at 30° to the horizontal. Use $g = 9.81 \text{ m/s}^2$.

1. Calculate the work done by gravity.
2. State the work done by the normal force.
3. Calculate the speed at the bottom.

Problem 10 Skateboard rolling to rest (medium)

A skateboarder of mass 60 kg stops rolling at 5.0 m/s on a flat rough road after 12 m. Use $g = 9.81 \text{ m/s}^2$.

1. Calculate the initial kinetic energy.
2. Calculate the average resisting force.
3. Calculate the coefficient of friction if this force is friction alone.

Problem 11 Curling stone (medium)

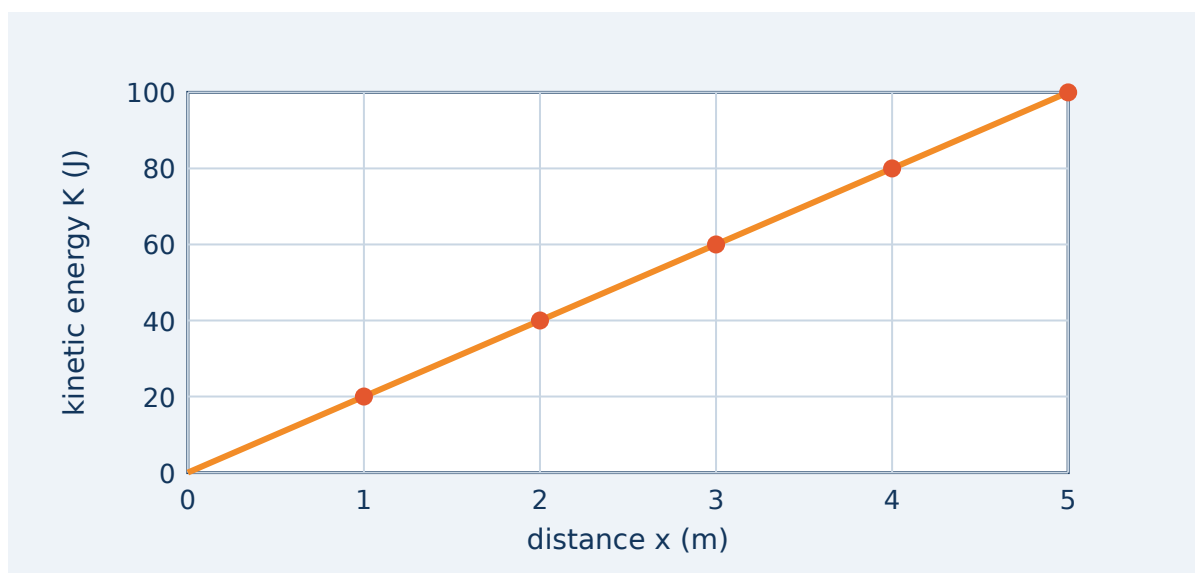
A curling stone of mass 19 kg is released at 2.4 m/s and slides 33 m to a stop on ice. Use $g = 9.81 \text{ m/s}^2$.

1. Calculate the kinetic energy at release.
2. Calculate the friction force.
3. Calculate the coefficient of kinetic friction.

Problem 12 Kinetic energy against distance (medium)

A cart starts from rest and a sensor records its kinetic energy as it moves under a constant net force. The graph shows the data.

1. Use the gradient to find the net force.
2. The cart's speed at $x = 5.0 \text{ m}$ is 6.0 m/s. Calculate its mass.
3. Calculate its acceleration.



Kinetic energy of the cart against distance.

Problem 13 Doubling the speed (medium)

A student claims: "A car travelling at 30 m/s needs only twice the stopping distance of the same car at 15 m/s, since the speed is doubled." The 1200 kg car brakes with a constant 6000 N.

1. Calculate the stopping distance from 15 m/s.
2. Calculate the stopping distance from 30 m/s.
3. Explain the student's mistake.

Problem 14 Stretching a spring (medium)

The force needed to stretch a spring is $F = kx$ with $k = 150 \text{ N/m}$.

1. Sketch the force-extension graph shape and state what its area represents.
2. Calculate the work done to stretch the spring from 0 to 0.20 m.
3. Calculate the work to stretch it from 0.20 m to 0.40 m.

Problem 15 Ranking kinetic energies (medium)

Rank these in order of kinetic energy and show the values.

1. A 0.15 kg ball at 30 m/s.
2. A 65 kg runner at 6.0 m/s.
3. A 4.0 g bullet at 400 m/s.

Problem 16 Pushing a crate up a ramp (hard)

Ngozi pushes a 25 kg crate 4.0 m up a ramp inclined at 20° to the horizontal, using a force parallel to the ramp. The crate moves at constant speed and $\mu_k = 0.25$. Use $g = 9.81 \text{ m/s}^2$.

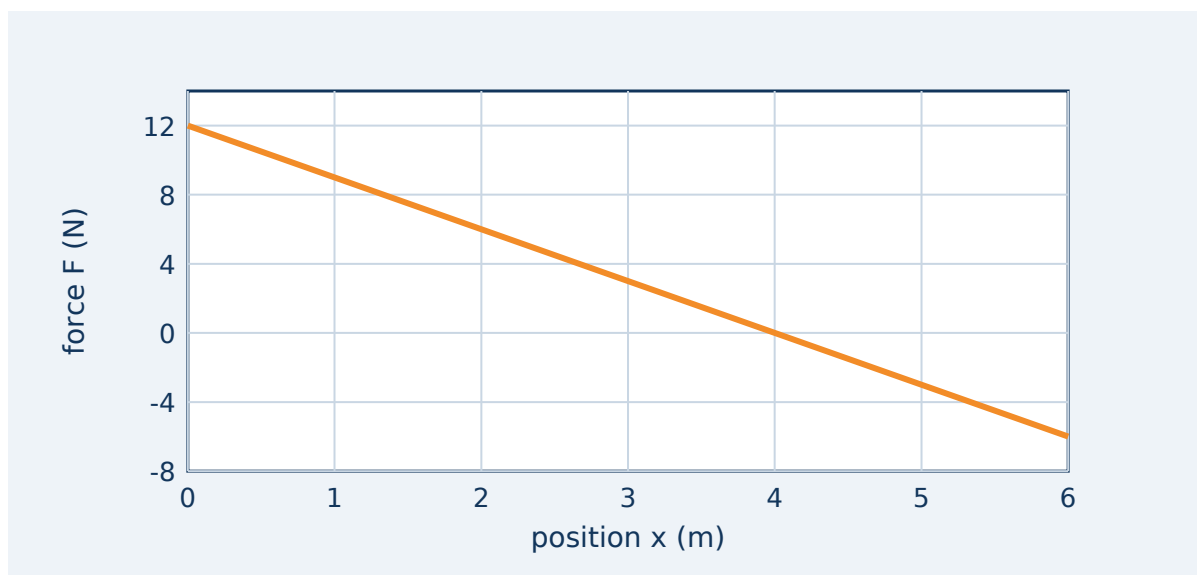
1. Calculate the work done by gravity.
2. Calculate the work done by friction.

3. Calculate the force Ngozi must apply.
4. Calculate the work she does and explain why the net work is zero.

Problem 17 Force that changes sign (hard)

A 2.0 kg cart moving at 3.0 m/s passes $x = 0$ as a force along the track varies as shown.

1. Calculate the work done between 0 and 4.0 m.
2. Calculate the work done between 4.0 m and 6.0 m.
3. Calculate the speed at $x = 6.0$ m.
4. State where the speed is greatest and calculate it.



Force on the cart against position.

Problem 18 Constant velocity paradox (hard)

Bilal pushes a box with a horizontal 40 N force across a rough floor at constant velocity for 6.0 m. A classmate argues: "The net work is zero, so Bilal did no work."

1. Calculate the work done by Bilal.
2. Calculate the work done by friction.
3. Write a short paragraph evaluating the classmate's claim, using the work-energy theorem.

Problem 19 Design: work and kinetic energy (hard)

Design an experiment to test $W_{\text{net}} = \Delta K$ for a dynamics cart of mass 0.500 kg pulled along a level track by a string over a pulley with a 0.050 kg hanging mass. Answer:

1. Which quantities are measured, and with what equipment?
2. How the friction on the track is dealt with.
3. Which graph to plot and what its gradient should be.
4. One systematic error and its effect on the gradient.

Problem 20 Falling through the air (hard)

A parachutist of mass 75 kg falls from rest. After 120 m the speed is 30 m/s. Later, the parachutist falls 300 m at a constant 6.0 m/s. Use $g = 9.81 \text{ m/s}^2$.

1. Calculate the work done by gravity and the change in kinetic energy over the first 120 m.
2. Calculate the work done by air resistance over this stage and the average drag force.
3. Calculate the work done by air resistance during the 300 m at constant speed.