

Kinetic and gravitational potential energy

Name: _____ Class: _____ Date: _____

Start here

0-5 minutes

Today: Choose and use kinetic/GPE equations, compare changes and rearrange for speed or vertical rise.

You need: Pen, a different-coloured pen, ruler and calculator. Reading, equations and figures are supplied.

Work from memory. Write directly in this booklet and show working and units.

1. Convert 750 g to kilograms.

Mass in kg:

2. A load is lifted and is stationary at the start and finish. Name the energy store that increases.

3. Use $E_k = 0.5mv^2$ to calculate the kinetic energy of a 2.0 kg object moving at 3.0 m/s.

Working:

Kinetic energy:

Stop for check 1. Wait for your teacher before moving on.

Try again A

Only if directed. Use the first 2 reading minutes, then continue on page 2.

Help: Use page 2's units/equations. Divide grams by 1000, name the store, then square speed before multiplying.

(a) Convert 1200 g to kg. (b) Name the store increased by lifting a stationary load. (c) Find E_k for a 4.0 kg object at 2.0 m/s, using $E_k = 0.5mv^2$.

When your teacher says, turn to page 2.

Choose the equation and use its units

5-15 minutes

For motion use $E_k = 0.5mv^2$: m is mass in kilograms and v is speed in metres per second. Near Earth, $GPE = mgh$ gives the increase when mass m rises through height h in metres; g is gravitational field strength in N/kg and is supplied in a question. Each result is in joules. Doubling speed at fixed mass quadruples kinetic energy, whereas doubling height doubles the gravitational change.

Change / unknown	Equation and essential meaning
Speed given	$E_k = 0.5mv^2$. Mass m in kg; speed v in m/s. Square speed first.
Speed unknown	$v^2 = 2E_k/m$, then take the positive square root to get v .
Vertical rise / fall	$GPE \text{ change} = mgh$. Use vertical height change h in m, not path/cable length.
Height unknown	$h = GPE \text{ change} / (mg)$. g is in N/kg; use the value supplied in that question.
Conversions / result	Grams $\div 1000$ = kilograms. Energy is in joules (J); speed is m/s.

Worked models - energy, height and finding speed

Follow three complete models. A 0.80 kg football moves at 5.0 m/s: find E_k . A 2.0 kg box rises 4.0 m with $g = 9.8$ N/kg: find its GPE increase. A different 4.0 kg trolley has $E_k = 18$ J: find its speed.

Football: $E_k = 0.5 \times 0.80 \times 5.0^2 = 10$ J. Box: $GPE \text{ increase} = 2.0 \times 9.8 \times 4.0 = 78.4$ J (78 J to two significant figures). Different trolley: $v^2 = 2E_k/m = 2 \times 18 / 4.0 = 9.0 \text{ m}^2/\text{s}^2$, so $v = 3.0$ m/s. Square a given speed before multiplying; take a positive square root when the unknown is speed. The box model uses its supplied 9.8, while later worksheet lifts explicitly supply 10.

Adapted from Energy Calculations and Power, section 1 and its GPE worked example under section 4. The square-root example is supplied for this lesson. Optional online reading.

Turn to page 3 for question 4.

Check which change is squared

15-20 minutes

4. Two separate comparisons: a trolley doubles its speed at unchanged mass; a load doubles its vertical rise at unchanged mass and g . Which pair gives the new energies relative to the originals? Choose a letter and justify both factors.

- A. Kinetic $\times 2$; GPE increase $\times 2$
- B. Kinetic $\times 4$; GPE increase $\times 4$
- C. Kinetic $\times 2$; GPE increase $\times 4$
- D. Kinetic $\times 4$; GPE increase $\times 2$

Chosen letter and kinetic-energy reason:

GPE reason:

Stop for check 2. Wait for your teacher before moving on.

Try again B

Only if directed. Complete B instead of questions 9-10 on page 4. Then answer questions 5-8 only on that page.

Help: Use page 2: mark the squared speed in E_k and the unsquared height in mgh . Apply each change only to its own equation.

In separate tests, a trolley triples its speed at unchanged mass and a load triples its vertical rise at unchanged mass and g . State the energy multiplication factor for each and explain using the equations.

Practice concerns a theatre team testing props. Total masses include the trolley and its load. Tests are separate. All required values are in the questions; no apparatus is needed.

Turn to page 4. If you completed B, leave questions 9-10 blank.

Apply kinetic energy to trolley settings

20-30 minutes

Complete questions 5-10, or 5-8 only if you completed B. Use total moving mass; the tests are separate.

5. A trolley and load have total mass 20 kg and speed 0.50 m/s. Calculate their kinetic energy.

Working and energy:

6. The same 20 kg trolley and load move at 1.0 m/s in a separate test. Calculate their kinetic energy.

Working and energy:

7. Another trolley and load have total mass 40 kg and speed 1.0 m/s. Calculate their kinetic energy.

Working and energy:

8. Use questions 5-7 to compare doubling speed at fixed mass with doubling mass at fixed speed. Give both energy comparisons and explain the difference.

Doubling speed at fixed mass:

Doubling mass at fixed speed:

9. A 48 kg trolley and load have kinetic energy 24 J. Calculate their speed.

Rearrangement and v^2 :

Speed after square root:

10. A small 800 g prop moves at 2.0 m/s. Calculate its kinetic energy.

Mass in kg and working:

Kinetic energy:

At about 30 minutes turn to page 5 for the independent check.

Pause and choose the vertical rise

30-33 minutes

11. A 6.0 kg load gains 180 J of gravitational potential energy. Use $g=10 \text{ N/kg}$. Calculate its vertical rise, then explain why a stated 5.0 m cable length is not the height to substitute.

Equation and working:

Vertical rise with unit:

Why cable length is not h :

Stop for check 3. Wait for your teacher before moving on.

Try again C

Only if directed. Complete C instead of questions 13-14 on page 6. Then do questions 12 and 15-17.

Help: Use page 2: $h = \text{GPE change} / (mg)$. Identify the vertical change of the load, not an object's full length.

A different 8.0 kg load gains 400 J of GPE with $g=10 \text{ N/kg}$. Find its vertical rise and explain why a 9.0 m cable length is not the required height.

After this check, everyone uses the supplied lift data on page 6 and ramp data on page 7.

Continue on page 6. If you used C, leave questions 13-14 blank.

Apply gravitational potential energy to a lift

33-45 minutes - continue practice

Figure 1 shows a scenery load rising vertically by 2.5 m. Use $g=10 \text{ N/kg}$ for questions 12-15. Questions 13 and 15 give separate lift tests.

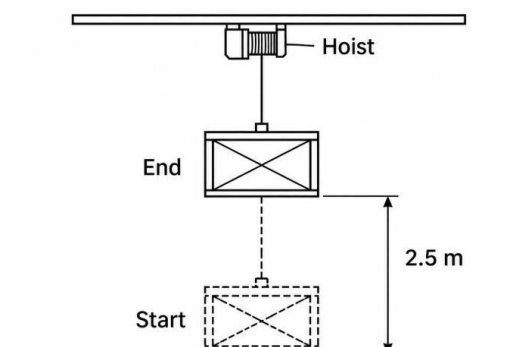


Figure 1: the 2.5 m arrow is the change in vertical position. Not to scale.

12. The scenery load in Figure 1 has mass 24 kg. Calculate its gravitational potential energy increase. Use $g=10 \text{ N/kg}$.

Working and GPE increase:

13. In a separate lift, a 24 kg load gains 360 J of gravitational potential energy. Use $g=10 \text{ N/kg}$. Calculate its vertical rise.

Rearrangement and vertical rise:

14. For the lift in question 12, a trainee uses the full cable length of 8.0 m instead of 2.5 m. Explain why this is wrong.

15. The 24 kg load rises 2.5 m in 3.0 s in one test and 6.0 s in another. Use $g=10 \text{ N/kg}$. Compare its gravitational potential energy gains and explain.

Gain in each test:

Explanation:

Finish practice with the ramp questions on page 7.

Read a ramp correctly

Finish practice by 45 minutes

A 2.0 kg sled starts from rest at A and slides to B. Its centre falls vertically by 0.80 m while it travels 2.0 m along the ramp. It does not rotate. Use $g=10$ N/kg. Only gravitational, kinetic and thermal stores change; no speed calculation is required here.

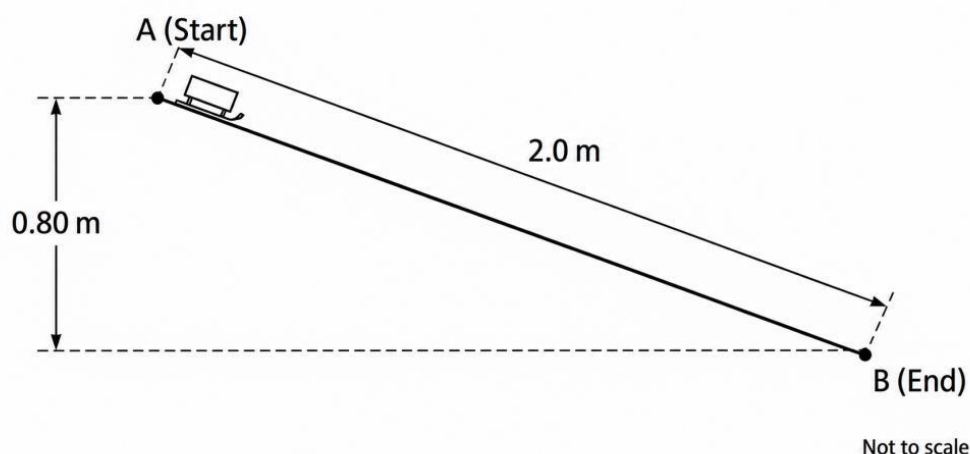


Figure 2: the ramp path and vertical drop are different distances. Not to scale.

16. Which distance in Figure 2 should be used to calculate the gravitational potential energy decrease? Explain.

Chosen distance and reason:

17. For this 2.0 kg sled and 0.80 m vertical drop, calculate the gravitational potential energy decrease. Use $g=10$ N/kg.

Working:

GPE decrease:

Check the meaning

Kinetic energy depends on speed squared. GPE change depends on vertical height change. A cable length, ramp path or time is not automatically h .

At 45 minutes turn to page 8 for review and the independent exit.

Review, then show what you can do

45-55 minutes review; 55-60 minutes independent exit

18. Correct practice in a different colour and explain the cause of one error using an equation and units. If all answers were correct, explain why a longer ramp with the same vertical drop does not change the sled's GPE decrease.

Independent exit - only when your teacher says

Cover earlier pages and previous answers. Complete question 19 independently.

19. (a) A 600 g prop has kinetic energy 10.8 J. Calculate its speed. (b) A separate 5.0 kg load gains 200 J of GPE. Use $g=10$ N/kg and calculate its vertical rise. (c) If the prop in (a) doubles its speed at fixed mass, what is its new kinetic energy? Explain the factor.

(a) Mass in kg and v^2 working:

(a) Speed after square root:

(b) Height equation, working and rise:

(c) New kinetic energy:

(c) Factor reason:

Stop for check 4. Wait for your teacher before moving on.

Write your name on page 1. Hand in the complete booklet, with working and corrections.

Try again D - next lesson

Leave this today. Your usual teacher may direct it next lesson.

Help: Next lesson revisit page 2. Cover the worked models before making this fresh independent attempt.

Next lesson: (a) A 400 g object has $E_k=3.2$ J. Find its speed. (b) A 3.0 kg load gains 90 J of GPE with $g=10$ N/kg. Find its rise. (c) The moving object halves its speed. Find its new E_k and explain the factor.

Hand your complete booklet to your teacher.