YEAR 9 PHYSICS, AQA GCSE, UNIT 2, PART 2

ENERGY STORES AND TRANSFERS

PART 2 OF 3

LESSONS 4–6: STRETCHING SPRINGS, THE ELASTIC POTENTIAL STORE, CONSERVATION OF ENERGY

3 LESSONS

2 PRACTICALS

2 NEW EQUATIONS

NAME _____ CLASS _____

TEACHER _____ TARGET GRADE _____

START HERE

HOW THIS BOOKLET WORKS

Energy is never made and never destroyed: it only moves from one store to another. This booklet shows you how to follow it, and how to calculate it. Keep the booklet: it is your classwork book *and* your revision guide.

DO NOW
Quick questions from earlier lessons. Remembering again is what makes it stick.

LEARN IT
The explanation, diagrams and worked examples. Read this again when you revise.

TRY IT
Practice that builds up: first with support, then on your own.

PRACTICAL
Record your measurements and work out results from them.

EXAM CORNER
AQA-style questions with a tip on how the marks are given.

REVISE IT
Summary, cover-and-answer questions and an "I can" check to colour in.

! **Two kinds of question to know.** When a sentence has a gap, the choices are printed straight after it, like this: Energy is measured in _____ **(joules / newtons / watts)**. When you see a box of choices, **draw a ring around** the correct one, as AQA exam papers ask. The unit of energy is | **the watt** | **the joule** | **the newton** | .

THE ROUTE THROUGH THIS PART

#	LESSON	WEEK
04	**Stretching springs** Two forces, elastic and inelastic, extension, $F = ke$, two graphs	2
05	**The elastic potential store** $E_e = \frac{1}{2} ke^2$; two-step questions; double the stretch, four times the energy	3
06	**Conservation of energy** Closed systems, falling and swinging, energy bar charts, dissipation	3

This booklet is Part 2 of 3: Lessons 4–6. The **equation toolkit** on the last page has every equation you have met so far, with formula triangles to help you rearrange.

Lesson

04 STRETCHING SPRINGS

AQA Physics 4.5.3; Combined Science 6.5.3

BIG QUESTION **A trampoline spring stretches a lot when you land on it. A car's suspension spring hardly moves when you sit in the car. What makes one spring stiffer than another?**

BY THE END YOU CAN

- explain why two forces are needed to stretch a spring
- tell elastic and inelastic deformation apart
- use $F = ke$ to find a force, a spring constant or an extension
- plot two graphs of the same results and find the spring constant

extension **spring constant (N/m)** **elastic deformation** **inelastic deformation** **limit of proportionality**

YOU WILL NEED

Clamp stand, spring, mass hanger, 100 g masses, metre rule, pointer, safety goggles.

REMEMBER

DO NOW

From earlier lessons. No notes!

1

In $E_p = mgh$, what does g stand for? Give its value on Earth.

2

A 2.0 kg box is lifted 3.0 m. Calculate the energy transferred to its gravitational potential store.

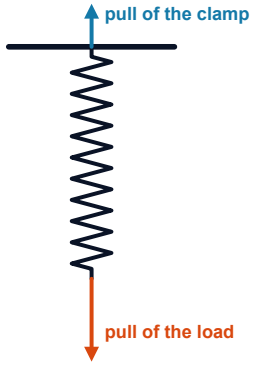
3

Convert 12 cm to metres.

EXPLAIN

STRETCH, SQUASH, BEND

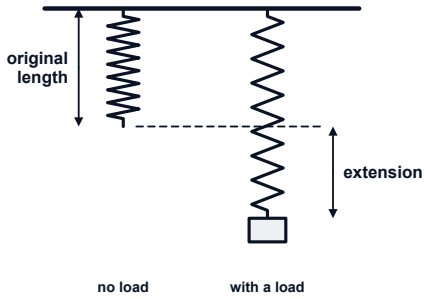
To stretch a spring and keep it still, you need **two forces**, one pulling each end. Here the clamp pulls the top up, and the load pulls the bottom down. With only one force, the spring would just move.



Elastic deformation: the spring goes back to its original length when the force is removed.
Inelastic deformation: the spring stays stretched.

EXTENSION

> ! **extension = stretched length − original length**
> Always record the **extension**, not the length.



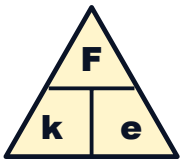
If a spring is 5.0 cm long with no load and 9.0 cm long with a load, its extension is 9.0 − 5.0 = 4.0 cm.

$$F = k\,e$$

force = spring constant × extension

F in newtons (N), k in newtons per metre (N/m), e in metres (m)

Rearranged: $k = \frac{F}{e}$ and $e = \frac{F}{k}$



The **spring constant** k tells you how stiff a spring is: the force needed for each metre of extension. A stiffer spring has a bigger k. In Lesson 5 you will use k to work out how much energy a stretched spring stores.

> ! **Hooke's law:** the extension of a spring is directly proportional to the force on it, as long as the **limit of proportionality** is not passed. Double the force, double the extension.

WORKED EXAMPLE

A spring stretches by 4.0 cm when a force of 2.0 N acts on it. Calculate its spring constant.

KNOW	F = 2.0 N, e = 4.0 cm = 0.040 m
REARRANGE	$k = \frac{F}{e}$
SUBSTITUTE	$k = \frac{2.0}{0.040}$
ANSWER	**k = 50 N/m**

YOUR TURN

A spring with k = 40 N/m is stretched by 0.15 m. Calculate the force.

KNOW

EQUATION

SUBSTITUTE

ANSWER

MASSES INTO FORCES AT THE BENCH

! Gravity pulls each kilogram down with 9.8 N, so each 100 g pulls down with 0.98 N. At the bench we round this: **each 100 g pulls down with about 1 N**. A mass is not a force: always record the force in newtons.

INVESTIGATE

PRACTICAL: STRETCHING A SPRING

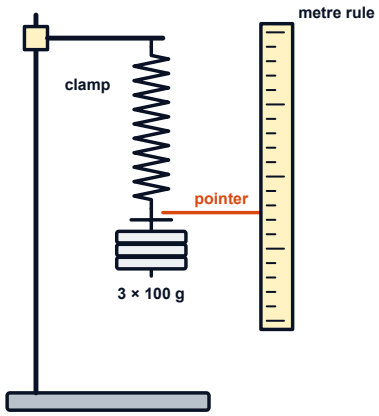
Work in pairs. Stand up while you work.

Before you start, write the question this practical answers and name its variables.

Question	
Independent variable	
Dependent variable	
Control variable	

STAY SAFE

- Wear safety goggles: a spring that slips off can whip.
- Keep your feet out from under the masses.
- Add masses gently. Do not let them drop.



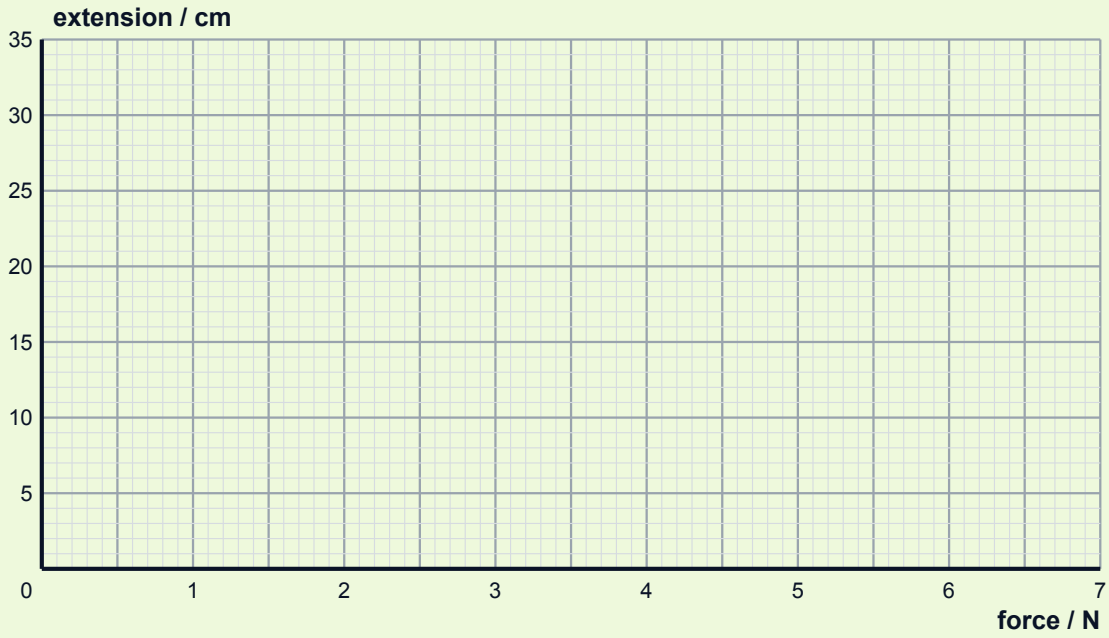
1. Line the pointer up with the metre rule. Record the original length.
2. Add a 100 g mass. Record the new length.
3. Repeat in 100 g steps up to 700 g.
4. Work out the force and the extension for each load.
5. Take the masses off one at a time. Does the spring go back to its original length?

6. Record your results. The force is about 1 N for each 100 g.

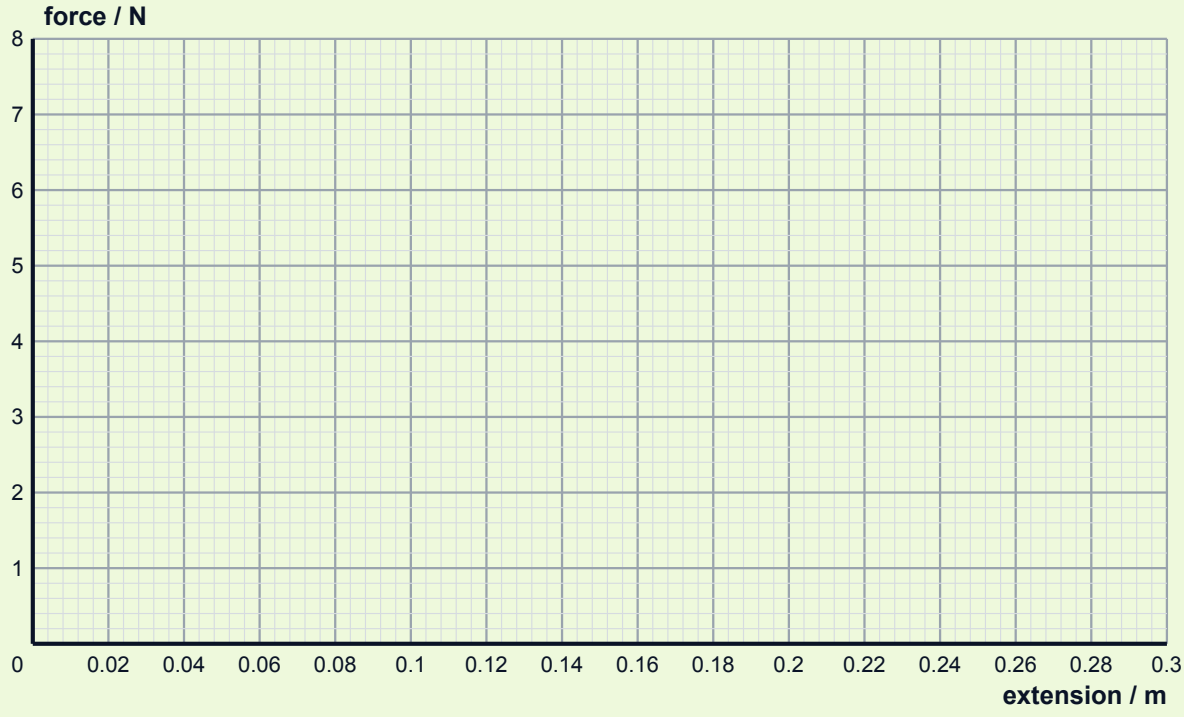
Mass added / g	Force / N	Length / cm	Extension / cm
0			
100			
200			
300			
400			
500			
600			
700			

TWO GRAPHS OF THE SAME RESULTS

7 **Graph 1: extension against force.** The independent variable goes on the x-axis, so the x-axis shows | **force** | **extension** | . Plot the points and draw a best-fit line. This graph answers our question: how does the extension change as the force increases?



8 **Graph 2: force against extension.** Swap the axes, so the dependent variable is now on the x-axis. We draw it this way because its gradient is the spring constant. Convert the extensions to metres first. Plot the points and draw a best-fit line.



WHAT THE TWO GRAPHS TELL YOU

9 Use graph 2 to find the spring constant. On graph 2, k is the gradient:

$$k = \frac{\text{change in force}}{\text{change in extension}}.$$

EQUATION	
SUBSTITUTE	
ANSWER	unit:

10 Both graphs show the same results. Complete the table to explain the difference.

	Y-AXIS	X-AXIS	THE GRADIENT TELLS YOU
Graph 1	extension	force	how stretchy the spring is / how stiff the spring is
Graph 2	force	extension	how stretchy the spring is / how stiff the spring is

11 A stiffer spring is tested. Draw a ring around the correct answer in each box.

On graph 1, its line would be **steeper** | **less steep**

On graph 2, its line would be **steeper** | **less steep**

12 Which reading is beyond the limit of proportionality? How can you tell from the graphs?

PRACTISE

TRY IT

1 Draw a ring around the correct answer in each box.

Elastic deformation means the object **goes back to its original shape** | **stays stretched**

A spring with a bigger spring constant is **stiffer** | **easier to stretch**

2 **SUPPORTED** A spring is 6.0 cm long. With a load on it, it is 9.5 cm long. Calculate the extension.

EQUATION	
SUBSTITUTE	
ANSWER	unit:

3 **SUPPORTED** Calculate the force needed to stretch a spring with k = 200 N/m by 0.050 m.

EQUATION	
SUBSTITUTE	
ANSWER	unit:

4 **ON YOUR OWN** A force of 3.0 N stretches a spring by 10 cm. Calculate its spring constant.

5 **ON YOUR OWN** A spring with k = 40 N/m has a force of 2.0 N on it. Calculate the extension. Give your answer in cm.

AQA-STYLE

EXAM CORNER

Write in full sentences. Show every step of a calculation.

> **Get the marks:** Convert the extension to metres before you divide.

13 A force of 5.0 N stretches a spring by 25 cm. Calculate the spring constant of the spring. **[3 marks]**

CONVERT	
EQUATION	
SUBSTITUTE	
ANSWER	unit:

14 Describe what happens to the extension of a spring when the force on it is doubled. Assume the limit of proportionality is not passed. **[2 marks]**

REVIEW LATER

REVISE IT

Use this box after the lesson and before tests.

SUMMARY

- Two forces are needed to stretch, squash or bend an object.
- Extension = stretched length − original length.
- $F = ke$: k in N/m, e in metres.
- On a force–extension graph (force on the y-axis), the gradient is k.
- Hooke's law holds up to the limit of proportionality.

COVER THE PAGE AND ANSWER

1 What is the extension of a spring?

2 Write the equation linking force, spring constant and extension.

3 What is the unit of spring constant?

4 What does inelastic deformation mean?

I CAN...

- explain why two forces are needed to stretch a spring
- calculate an extension from two lengths
- use $F = ke$ and its rearrangements
- plot both graphs and find k from the gradient

Lesson

05 THE ELASTIC POTENTIAL STORE

AQA Physics 4.1.1.2, 4.5.3; Combined Science 6.1.1.2, 6.5.3

BIG QUESTION **An archer pulls a bowstring back twice as far. Does the arrow get twice as much energy, or more?**

BY THE END YOU CAN

- calculate elastic potential energy with $E_e = \frac{1}{2} k e^2$
- find k first when you are given a force
- explain why doubling the extension gives four times the energy
- say when the equation can be used

elastic potential store **work done** **compression**

BUNGEE

A bungee cord is a giant elastic band. As the jumper falls, the cord stretches and fills its elastic potential store. That slows the jumper down safely, then springs them back up.

REMEMBER

DO NOW

From earlier lessons. No notes!

1

A spring has k = 50 N/m. Calculate the force that stretches it by 0.10 m.

2

What is the unit of spring constant?

3

Doubling the speed makes the kinetic energy _____ **(2 / 4 / 8)** times bigger.

EXPLAIN

ENERGY IN A STRETCHED SPRING

When you stretch or squash a spring, you **do work** on it: your force transfers energy to it. The energy is stored in the spring's **elastic potential store**. Let go, and the spring gives the energy back.

$$E_e = \frac{1}{2}\,k\,e^2$$

elastic potential energy = 0.5 × spring constant × (extension)²

E_e in J, k in N/m, e in metres (m)

Only the extension is squared. For a squashed spring, e is how much shorter it is. In this unit you use the equation to calculate the energy.

! The equation works only up to the **limit of proportionality**. Beyond it, the spring may be permanently stretched and will not give all the energy back.

WORKED EXAMPLE

A spring with k = 50 N/m is stretched by 0.040 m. Calculate the energy in its elastic potential store.

KNOW	k = 50 N/m, e = 0.040 m
EQUATION	$E_e = \frac{1}{2}\,k\,e^2$
SUBSTITUTE	$E_e = 0.5 \times 50 \times 0.040^2$
ANSWER	$E_e = 0.04$ J

YOUR TURN

A spring with k = 200 N/m is squashed by 0.050 m. Calculate the energy stored.

KNOW

EQUATION

SUBSTITUTE

ANSWER

GIVEN A FORCE? FIND k FIRST

WORKED EXAMPLE

A force of 3.0 N stretches a spring by 10 cm. Calculate the energy stored.

KNOW	F = 3.0 N, e = 10 cm = 0.10 m
STEP 1	$k = \frac{F}{e} = \frac{3.0}{0.10} = 30$ N/m
STEP 2	$E_e = \frac{1}{2}\,k\,e^2 = 0.5 \times 30 \times 0.10^2$
ANSWER	$E_e = 0.15$ J

YOUR TURN

A force of 4.0 N stretches a spring by 0.20 m. Calculate the energy stored.

KNOW

STEP 1

STEP 2

ANSWER

DOUBLE THE STRETCH, FOUR TIMES THE ENERGY

EXTENSION OF A 50 N/M SPRING	e^2	E_e
0.040 m	0.0016	0.04 J
0.080 m (2 × further)	0.0064	0.16 J (4 × more)
0.120 m (3 × further)	0.0144	0.36 J (9 × more)

This is the same pattern as kinetic energy, because the extension is squared. **Why?** The further you stretch a spring, the harder you have to pull. So each extra centimetre takes more work than the one before.

PRACTISE

TRY IT

1 Draw a ring around the correct answer in each box.

$E_e = \frac{1}{2}\,k\,e^2$ can only be used up to the

limit of proportionality	**top of the ruler**	**point where the spring snaps**

Tripling the extension makes the energy stored

3 times bigger	**6 times bigger**	**9 times bigger**

2 SUPPORTED A spring with k = 80 N/m is stretched by 0.10 m. Calculate the energy stored.

EQUATION	
SUBSTITUTE	
ANSWER	unit:

3 **SUPPORTED** A spring in a toy car has k = 400 N/m and is squashed by 20 mm. Calculate the energy stored. *Convert mm to m: divide by 1000.*

CONVERT	
EQUATION	
SUBSTITUTE	
ANSWER	unit:

4 **ON YOUR OWN** A force of 6.0 N stretches a spring by 0.15 m. Calculate the energy stored.

5 Raj's spring has k = 30 N/m. What did he do wrong? Calculate the correct answer.

Raj: e = 10 cm, so the energy stored is 0.5 × 30 × 10² = 1500 J.

6 **CHALLENGE** Spring A has k = 100 N/m and is stretched by 0.10 m. Spring B has k = 50 N/m and is stretched by 0.20 m. Which spring stores more energy? Show your working.

INVESTIGATE

YOUR OWN SPRING

Use the spring constant you found in Lesson 4.

7 My spring constant from Lesson 4: k = _____ N/m. Calculate the energy stored at each extension.

Extension / m	e^2 / m²	E_e / J
0.05		
0.10		
0.20		

8 Check: did doubling the extension from 0.10 m to 0.20 m give four times the energy?

yes | **no** Show how you know.

9 Could you use $E_e = \frac{1}{2} k e^2$ for the 700 g reading in Lesson 4? **yes** | **no**

Explain.

AQA-STYLE

EXAM CORNER

Write in full sentences. Show every step of a calculation.

> **Get the marks:** Square only the extension. Give the unit.

10 A catapult has a spring constant of 500 N/m. It is stretched by 0.12 m. Calculate the energy in its elastic potential store. **[2 marks]**

EQUATION	
SUBSTITUTE	
ANSWER	unit:

11 Explain why $E_e = \frac{1}{2}ke^2$ cannot be used once the spring has passed its limit of proportionality. **[2 marks]**

REVIEW LATER

REVISE IT

Use this box after the lesson and before tests.

SUMMARY

- $E_e = \frac{1}{2}ke^2$: k in N/m, e in metres, E_e in J.
- The work done stretching a spring is stored in its elastic potential store.
- Given a force and an extension? Find $k = \frac{F}{e}$ first.
- 2 × the extension gives 4 × the energy.
- Only up to the limit of proportionality.

COVER THE PAGE AND ANSWER

1 Write the equation for elastic potential energy.

2 What unit must the extension be in?

3 The extension doubles. What happens to the energy stored?

4 When can the equation not be used?

I CAN...

- calculate $E_e = \frac{1}{2}ke^2$ with the extension in metres
- find k from a force first, then calculate E_e
- explain why doubling the extension gives four times the energy

Lesson

06 CONSERVATION OF ENERGY

AQA Physics 4.1.2.1, 4.1.1.1; Combined Science 6.1.2.1, 6.1.1.1

BIG QUESTION **A heavy pendulum is pulled back to touch your nose and let go. When it swings back, will it hit you?**

BY THE END YOU CAN

- state the principle of conservation of energy
- follow energy from one store to another in a closed system
- use conservation of energy in calculations
- draw energy bar charts
- explain why real systems lose some useful energy

conservation of energy **closed system** **dissipated** **energy bar chart**

YOU WILL NEED

Practical: clamp stand, string, pendulum bob, metre rule, a phone to film the swing.

REMEMBER

DO NOW

From earlier lessons. No notes!

1

A 1.0 kg ball is lifted 2.0 m. Calculate the energy transferred to its gravitational potential store.

2

A 2.0 kg ball moves at 3.0 m/s. Calculate the energy in its kinetic store.

3

A stretched spring stores energy in its _____ **(kinetic / elastic potential)** store.

EXPLAIN

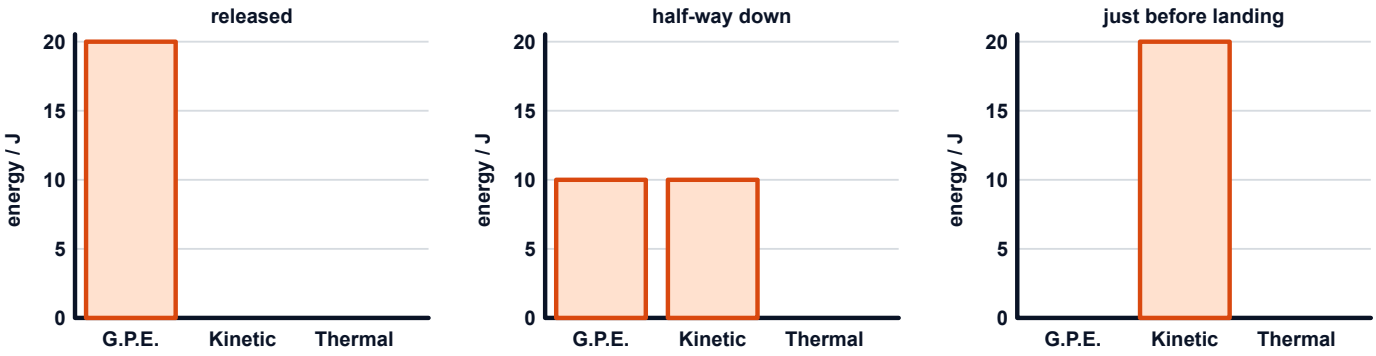
ENERGY IS NEVER LOST

! **Conservation of energy:** energy can be transferred usefully, stored or dissipated, but it cannot be created or destroyed.

In a **closed system**, the total energy never changes. Energy only moves from one store to another.

A FALLING BALL

As a ball falls, energy is transferred from its gravitational potential (G.P.E.) store to its kinetic store. If we ignore air resistance, all the energy that leaves the G.P.E. store arrives in the kinetic store. An **energy bar chart** shows this: the bars change, but the total stays the same.



WORKED EXAMPLE

A 0.50 kg ball is dropped from 3.0 m. Calculate the energy in its kinetic store just before it lands. Ignore air resistance.

IDEA

energy gained by the kinetic store = energy lost from the G.P.E. store

EQUATION

$$E_p = m\,g\,h$$

SUBSTITUTE

$$E_p = 0.50 \times 9.8 \times 3.0 = 14.7 \text{ J}$$

ANSWER

$$E_k = 14.7 \text{ J}$$

YOUR TURN

A 2.0 kg rock falls 5.0 m. Calculate the energy in its kinetic store just before it lands. Ignore air resistance.

IDEA

EQUATION

SUBSTITUTE

ANSWER

FINDING A HEIGHT

WORKED EXAMPLE

A 0.25 kg ball is thrown straight up with 20 J in its kinetic store. Calculate the greatest height it reaches. Ignore air resistance.

IDEA	at the top, all 20 J is in the G.P.E. store
REARRANGE	$h = \frac{E_p}{m\,g}$
SUBSTITUTE	$h = \frac{20}{0.25 \times 9.8}$
ANSWER	**h = 8.2 m**

YOUR TURN

A 0.10 kg ball is thrown straight up with 4.9 J in its kinetic store. How high does it go? Ignore air resistance.

IDEA

REARRANGE

SUBSTITUTE

ANSWER

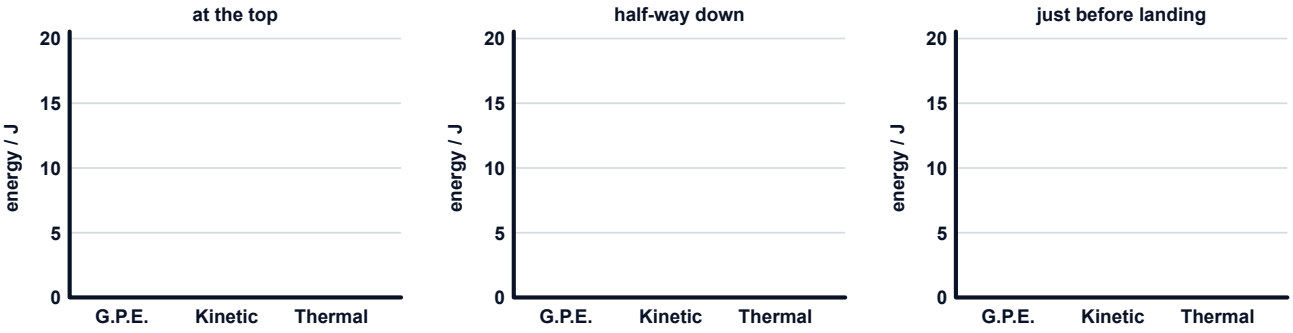
REAL SYSTEMS: SOME ENERGY IS DISSIPATED

In real life, air resistance and friction transfer some energy to the **thermal store** of the surroundings. This energy is not destroyed, but it is spread out and we cannot use it again. We say it is **dissipated**. That is why a pendulum swings a little lower each time, and why it will not hit your nose.

PRACTISE

TRY IT

1. A ball has 20 J in its G.P.E. store at the top. Ignore air resistance. Draw the bars at each moment.



2 Complete the sentences. The choices are after each gap.

At the top of its swing, a pendulum has most energy in its _____ **(kinetic / gravitational potential)** store.

At the bottom of its swing, it has most energy in its _____ **(kinetic / gravitational potential)** store.

The total energy _____ **(goes up / goes down / stays the same)** if we ignore air resistance.

3 **ON YOUR OWN** A 0.20 kg apple falls 2.5 m from a tree. Calculate the energy in its kinetic store just before it lands. Ignore air resistance.

4 **CHALLENGE** A toy launcher has a spring with k = 200 N/m, squashed by 0.050 m. It fires a 10 g ball straight up. Calculate the greatest height the ball could reach.

5 Explain why Mo is wrong.

Mo: The pendulum swings lower each time, so energy is being destroyed.

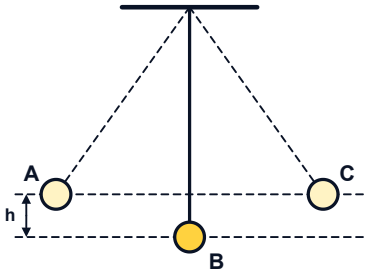
INVESTIGATE

PRACTICAL: DOES THE PENDULUM KEEP ITS ENERGY?

Every reading is a height, so you do not need fast timing.

STAY SAFE

- Clamp the stand firmly so it cannot tip.
- Let the bob go from rest; never push it.
- Keep clear of the swing.



1. Hang the bob. Note the height of its lowest point on the metre rule.
2. Pull the bob to the side until it is 0.20 m higher than its lowest point (A). Let go.
3. Read the height it reaches on the other side (C). Filming helps.
4. Let it keep swinging. Read the height it reaches after 10 swings.

6 Mass of the bob = _____ kg. Record the heights and calculate the energy in the G.P.E. store each time.

Moment	Height above lowest point / m	E_p / J
Released	**0.20**	
After 1 swing		
After 10 swings		

7 On the first swing, how much energy is in the bob's kinetic store at the lowest point B? Explain.

8 After 10 swings, the energy has been **created** | **destroyed** | **dissipated** . Where has it gone?

AQA-STYLE

EXAM CORNER

Write in full sentences. Show every step of a calculation.

Get the marks: In part (b), say why the two energies are equal.

9 A diver of mass 60 kg stands on a board 10 m above the water. Gravitational field strength = 9.8 N/kg. **[2 marks]**

(a) Calculate the energy in the diver's gravitational potential store.

EQUATION	
SUBSTITUTE	
ANSWER	unit:

10 (b) The diver falls into the water. Ignoring air resistance, how much energy is in the diver's kinetic store just before they reach the water? Give a reason. **[2 marks]**

11 (c) In real life, the energy in the kinetic store is a little less. Explain why. **[2 marks]**

REVIEW LATER

REVISE IT

Use this box after the lesson and before tests.

SUMMARY

- Energy cannot be created or destroyed, only transferred, stored or dissipated.
- In a closed system the total energy stays the same.
- Falling: G.P.E. store → kinetic store. Rising: kinetic store → G.P.E. store.
- Energy bar charts: the bars change, the total stays the same.
- Real systems dissipate some energy to the thermal store of the surroundings.

COVER THE PAGE AND ANSWER

1 State the principle of conservation of energy.

2 A ball falls and loses 12 J of G.P.E. Ignoring air resistance, how much does its kinetic store gain?

3 Why does a pendulum swing lower each time?

4 What does an energy bar chart show?

I CAN…

- state the principle of conservation of energy
- use energy lost = energy gained in calculations
- draw energy bar charts
- explain why real systems dissipate energy

REFERENCE

KEY WORDS

Learn the meaning and the spelling. In exams, precise words earn marks: say “transferred to the thermal store of the surroundings”, never “lost”.

Extension L4: Stretched length minus original length

Spring constant (k) L4: The force needed for each metre of extension, in N/m; a stiffer spring has a bigger k

Elastic deformation L4: The object goes back to its original shape when the force is removed

Inelastic deformation L4: The object stays stretched or bent when the force is removed

Limit of proportionality L4: The point beyond which extension is no longer directly proportional to force

Elastic potential store L5: Energy an object has because it is stretched or squashed

Conservation of energy L6: Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed

Dissipated L6: Spread out to the surroundings, usually to the thermal store, where it is no longer useful

FINISH

PROGRESS TRACKER

Colour one circle for each statement: **red** = not yet, **amber** = getting there, **green** = I can do this without help. Revisit your reds first.

I CAN…	R / A / G
04: Stretching springs	
explain why two forces are needed to stretch a spring	
calculate an extension from two lengths	
use $F = k\,e$ and its rearrangements	
plot both graphs and find k from the gradient	
05: The elastic potential store	
calculate $E_e = \frac{1}{2}\,k\,e^2$ with the extension in metres	
find k from a force first, then calculate E_e	
explain why doubling the extension gives four times the energy	
06: Conservation of energy	
state the principle of conservation of energy	
use energy lost = energy gained in calculations	
draw energy bar charts	
explain why real systems dissipate energy	

CHECK YOURSELF

QUICK ANSWERS

Answers to the “Do now” and “Cover the page” questions, so you can check yourself when revising. Answers to the longer questions are in your teacher's answer edition.

LESSON 4: STRETCHING SPRINGS

DO NOW

1. Gravitational field strength: 9.8 N/kg.
2. $E_p = 2.0 \times 9.8 \times 3.0$
   $E_p = 58.8$ J
3. 0.12 m

COVER THE PAGE

1. Its stretched length minus its original length.
2. $F = ke$
3. Newtons per metre (N/m).
4. The object does not go back to its original shape when the force is removed.

LESSON 5: THE ELASTIC POTENTIAL STORE

DO NOW

1. $F = ke = 50 \times 0.10 = 5.0$ N
2. N/m
3. 4

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1. $E_e = \frac{1}{2}ke^2$
2. Metres (m).
3. It becomes 4 times bigger.
4. Beyond the limit of proportionality.

LESSON 6: CONSERVATION OF ENERGY

DO NOW

1. $E_p = 1.0 \times 9.8 \times 2.0$
   $E_p = 19.6$ J
2. $E_k = 0.5 \times 2.0 \times 3.0^2$
   $E_k = 9.0$ J
3. elastic potential

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1. Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
2. 12 J
3. Some energy is dissipated to the thermal store of the surroundings by air resistance and friction.
4. How much energy is in each store at one moment.

REFERENCE

EQUATION TOOLKIT

Every equation from Lessons 1–6. AQA prints all of them on the equation sheet in the exam, but you still need to know what each symbol means, its unit, and how to use it. Use $g = 9.8\ \text{N/kg}$.

1. Cover the quantity you want to find.
2. What is left side by side? **Multiply**.
3. One above the other? **Divide** the top by the bottom.

Example: to find h from $E_p = m\,g\,h$, cover h. E_p is above m and g, so $h = \dfrac{E_p}{m\,g}$. Kinetic and elastic potential energy have no triangle: in this unit you only use them to calculate the energy.

$E_k = \frac{1}{2}\,m\,v^2$

Lesson 2

kinetic energy = 0.5 × mass × (speed)²

J, kg, m/s

Use it to calculate the energy. Only the speed is squared.

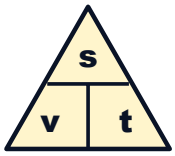
$s = v\,t$

Lesson 2

distance travelled = speed × time

m, m/s, s

$v = \dfrac{s}{t}$ and $t = \dfrac{s}{v}$



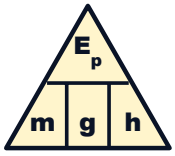
$E_p = m\,g\,h$

Lesson 3

gravitational potential energy = mass × gravitational field strength × height

J, kg, N/kg, m

$h = \dfrac{E_p}{m\,g}$ and $m = \dfrac{E_p}{g\,h}$



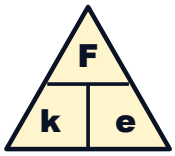
$F = k\,e$

Lesson 4

force = spring constant × extension

N, N/m, m

$k = \dfrac{F}{e}$ and $e = \dfrac{F}{k}$



$E_e = \frac{1}{2}\,k\,e^2$

Lesson 5

elastic potential energy = 0.5 × spring constant × (extension)²

J, N/m, m

Use it to calculate the energy. Only the extension is squared.

1

Write what you know. Convert first: g → kg, cm → m, kJ → J.

2

Write the equation in symbols.

3

Rearrange if you need to, then substitute the numbers.

4

Give the answer with a unit. Ask: is it sensible?