Energy

Key Stage 4 Revision Programme

Pupil Name	
Handbook Designed by	Dr Edmunds

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1 (Baseline)			T2D
2			T2D
3			T2D
4			T2D
5			T2D
6 (Final Assignment)			T2D
7 (Feedback)			T2D

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
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Course Rationale

Energy is the stuff that makes things happen.

The concept of energy is one of the most far-reaching and powerful ideas in all of physics. It allows us to understand and make predictions about a huge range of different phenomena - from the change in temperature of a mug of tea, to the speed of a rocket launched into space.

We can calculate all these things thanks to the *law of conservation of energy*. This law says that energy can be transferred from one form to another but can *never* be created or destroyed. Take a light bulb, for example. Some of the electrical energy used to power the bulb is transferred into useful light energy, while some of it is transferred to heat, or even to sound. However, because we can't create more energy, or make any disappear, the *total* energy (light + heat + sound) *must* be equal to the amount of electrical energy that we originally supplied.

No exceptions to this rule have ever been found. It is one of the fundamental laws that governs our universe, and as such, it forms the foundation for our understanding of it.

This course is designed to help you master the concept of energy in GCSE physics. In order to do this, we will reduce the topic into its smallest building blocks, that you will then practise and perfect. This approach is based on a simple idea—to master something, you need to break it down into its fundamentals, practise it piece by piece, and only then, put it all back together...

Sports stars and musicians are used to learning this way. For example, world-class footballers don't just improve by playing matches—they also train their footwork and ball skills through drills and set pieces. Similarly, before they take to the stage, master pianists train by practising scales and rehearsing compositions bar by bar. This method of *deliberate practice* applies to mastering concepts in physics too — and that's the approach we will take in this course. By the end of it, I hope you will feel like an energy *expert*, confident to take on any question your GCSE exam might put in your path!

Specification

Energy, power & efficiency

1. Energy stores		
1	Conservation of energy [4.1.2.1]	Energy can be transferred between different energy stores, but it cannot be created or destroyed.
2	Kinetic energy [4.1.1.2]	Kinetic energy is the energy an object has due to its motion. $$E_k = \frac{1}{2}mv^2$$ Kinetic energy, E_k in joules (J) Mass, m in kilograms (kg) Velocity, v in metres per second (m/s)
3	Elastic potential energy [4.1.1.2]	Elastic potential energy is the energy stored in a stretched, or compressed, spring. $$E_e = \frac{1}{2}ke^2$$ Elastic potential energy, E_e in joules (J) Spring constant, k in newtons per metre (N/m) Extension, e in metres (m)
4	Gravitational potential energy [4.1.1.2]	Gravitational potential energy is the energy an object has due to being raised above the ground. $$E_p = mgh$$ Gravitational potential energy, E_p in joules (J) Mass, m in kilograms (kg) Gravitational field strength, g in newtons per kilogram (N/kg) Height above the ground, h in metres (m)

Tutorial 1: Baseline Assessment

Keywords: kinetic, energy, mass, velocity

In this tutorial we will check your current understanding of energy, and identify any areas for improvement.

Remember...

- Attempt every question
- Always show your working
- Check your calculations
- Give units with every numerical answer
- Look at the marks available for each question to help you plan your time.

Good luck!

Tutorial 2: Rearranging equations

Keywords: Subject, equation, rearrange, multiply, divide

Objectives this tutorial:

A) Rearrange equations like V = I × R

B) Rearrange equations like P = W ÷ t

C) Rearrange more complicated equations like $E_k = 0.5 \times m \times v^2$

Do now: Write down as many symbols and units as you can for:

a) Power
b) Energy
c) Charge
d) Voltage
e) Mass
f) Resistance
g) Speed
h) Height
i) Work done
j) Current
k) Time
l) Gravitational field strength
m) Density
n) Volume

Objective A: Rearrange equations like V = I × R

Worked example 1

Consider the equation 10 = 5 × 2. This equation is correct, but let's say we want to re-arrange to give an equation for 2. To do this, we look at the equation and see if anything is multiplying the number 2. In this case it is the number 5. We can divide both sides of the equation by this number:

$$\frac{10}{5} = \frac{5 \times 2}{5}$$

Here, we can cancel the number 5 because 5 divided by 5 is equal to one. We now end up with:

$$\frac{10}{5} = 2$$

Which is still a correct equation; we have correctly re-arranged it! If you're ever not sure if you've rearranged an equation correctly you can put in real numbers to check.

Worked example 2

Re-arrange the equation V = I × R to make I the subject of the equation.

Step 1: Divide both sides of the equation by R.

$$\frac{V}{R} = \frac{I \times R}{R}$$

Step 2: Cancel R on the right hand side of the equation.

$$\frac{V}{R} = I$$

Worked example 3
Re-arrange the equation Ep = m × g × h to make m the subject of the equation.

Step 1: Divide both sides of the equation by g × h.

$$\frac{E_p}{g \times h} = \frac{m \times g \times h}{g \times h}$$

Step 2: Cancel g × h on the right hand side of the equation.

$$\frac{E_p}{g \times h} = m$$

Practice A: Rearrange equations like V = I × R

1) Re-arrange **V = I × R** to make R the subject of the equation.

2) Re-arrange **P = I × V** to make V the subject of the equation.

3) Re-arrange **E = Q × V** to make Q the subject of the equation.

4) Re-arrange **E_p = m × g × h** to make h the subject of the equation.

5) Re-arrange **P = I^2 × R** to make R the subject of the equation.

Assessment A: Rearrange equations like V = I × R

Which statement is correct?
Re-arrange **E_p = m × g × h** to make g the subject of the equation.

A	$g = \frac{E_p \times m}{h}$
B	$g = \frac{E_p}{m \times h}$
C	$g = \frac{E_p \times h}{m}$
D	$g = \frac{m \times h}{E_p}$

Objective B: Rearrange equations like P = W ÷ t

Worked example 1
Consider the equation **5 = 10 ÷ 2**. This equation is again correct, but let's say we want to re-arrange to give an equation for 10. To do this, we look at the equation and see if anything is dividing the number 10. In this case it is the number 2. We can multiply both sides of the equation by this number:

$$5 \times 2 = \frac{10}{2} \times 2$$

Here, we can cancel the number 2 because 2 divided by 2 is equal to one. We now end up with:

$$5 \times 2 = 10$$

Which is still a correct equation; we have correctly re-arranged it! If you're ever not sure if you've rearranged an equation correctly you can put in real numbers to check.

Worked example 2
Re-arrange the equation **P = W ÷ t** to make W the subject of the equation.

Step 1: Multiply both sides of the equation by t.

$$P \times t = \frac{W}{t} \times t$$

Step 2: Cancel t on the right hand side of the equation.

$$P \times t = W$$

Worked example 3
Re-arrange the equation **P = W ÷ t** to make t the subject of the equation.

Step 1: Multiply both sides of the equation by t.

$$P \times t = \frac{W}{t} \times t$$

Step 2: Cancel t on the right hand side of the equation.

$$P \times t = W$$

Step 3: Divide both sides of the equation by P. (note: now the problem is the same as in objective A)

$$\frac{P \times t}{P} = \frac{W}{P}$$

Step 4: Cancel P on the left hand side of the equation.

$$t = \frac{W}{P}$$

Practice B: Rearrange equations like P = W ÷ t

1) Re-arrange **P = E ÷ t** to make E the subject of the equation.

2) Re-arrange **ρ = m ÷ V** to make m the subject of the equation.

3) Re-arrange **P = E ÷ t** to make t the subject of the equation.

4) Re-arrange **ρ = m ÷ V** to make V the subject of the equation.

5) Re-arrange **s = d ÷ t** to make d the subject of the equation.

Assessment B: Rearrange equations like P = W ÷ t

Which statement is correct?
Re-arrange **g = W ÷ m** to make m the subject of the equation.

A	$m = \frac{W}{g}$
B	$m = \frac{g}{W}$
C	$m = \frac{g}{m}$
D	$m = \frac{W}{m}$

Objective C: Rearrange more complicated equations like $E_k = 0.5 \times m \times v^2$

Worked example 1

Re-arrange the equation $\mathbf{E_k = 0.5 \times m \times v^2}$ to make v the subject of the equation.

Step 1: Divide both sides of the equation by 0.5 × m.

$$\frac{E_k}{0.5 \times m} = \frac{0.5 \times m \times v^2}{0.5 \times m}$$

Step 2: Cancel 0.5 × m on the right hand of the equation.

$$\frac{E_k}{0.5 \times m} = v^2$$

Step 3: Square root both sides of the equation.

$$\sqrt{\frac{E_k}{0.5 \times m}} = v$$

Worked example 2

Re-arrange the equation $\mathbf{s = u \times t + 0.5 \times a \times t^2}$ **to** make u the subject of the equation.

Step 1: Take $0.5 \times a \times t^2$ away from both sides of the equation.

$$s - 0.5 \times a \times t^2 = u \times t$$

Step 2: Divide both sides of the equation by t

$$s - 0.5 \times a \times t = u$$

Practice C: Rearrange more complicated equations like $E_k = 0.5 \times m \times v^2$

1) Rearrange the equation $\mathbf{E_e = 0.5 \times k \times e^2}$ to give an equation for e.

2) Rearrange the equation $\mathbf{Ee = 0.5 \times k \times e^2}$ to give an equation for k.

3) Re-arrange the equation **Ek = 0.5 × m × v²** to make m the subject of the equation.

4) Rearrange the equation **s = u × t + 0.5 × a × t²** to make a the subject of the equation.

Assessment C: Rearrange more complicated equations like $E_k = 0.5 \times m \times v^2$

Which statement is correct?
Re-arrange $\mathbf{a^2 + b^2 = c^2}$ to give an equation for b.

A	$b = c^2 - a^2$
B	$b = \sqrt{c^2 - a^2}$
C	$b = \sqrt{c^2 + a^2}$
D	$b = c^2 + a^2$

Tutorial 3: Kinetic energy

Keywords: kinetic, energy, mass, velocity

Objectives this tutorial:
A) Define kinetic energy.
B) Calculate kinetic energy.
C) Calculating mass and velocity.

Do now: Which has more kinetic energy when moving at a speed of 5 m/s; a 5 kg medicine ball or a 10 kg medicine ball?

Under what circumstances could their kinetic energies be equal?

Objective A: Defining kinetic energy

Kinetic energy is the energy of movement and is defined by the equation $E_k = 0.5 \times m \times v^2$, where:

- E_k is the kinetic energy (with units of Joules)
- *m* is mass (in kg)
- *v* is velocity (m/s)

The larger the mass of an object, or the faster the object is moving, the more kinetic energy it has.

Practice A: Defining kinetic energy

1) State the equation for kinetic energy, defining the terms used.

2) Write a sentence defining kinetic energy in words.

3) Rank the following from low to high kinetic energy: an aeroplane, somebody on a bicycle, a truck on the motorway and a football.

4) A car accelerates on a road. Explain whether the kinetic energy of the car changes.

5) A lorry is driving along a motorway and accidentally drops some parcels from the back. Explain what happens to the kinetic energy of the lorry.

Assessment A: Defining kinetic energy

Which statement is incorrect?

A	The faster an object is travelling, the more kinetic energy it has.
B	$m = E_k/(0.5 \times v^2)$.
C	If you change the mass of an object, its kinetic energy does not change.
D	Mass has units of kg, speed has units of m/s and kinetic energy has units of Joules.

Objective B: Calculating kinetic energy

Worked example 1

Cristiano Ronaldo kicks a football of mass 500 g at a speed of 40 m/s. Calculate the kinetic energy of the football.

$m = 500\ g = 0.5\ kg$ ← conversion
$v = 40\ m/s$

Study tip
Don't forget to convert non-standard units into standard units!

$E_k = 0.5 \times m \times v^2$

$E_k = 0.5 \times 0.5 \times 40^2$
$E_k = 400$ Joules ← units

Worked example 2

A bullet of mass 10.5 g has a velocity of 1,500 mph. How much kinetic energy does it have? (1 mile = 1.6 km.)

$m = 10.5\ g = 0.0105\ kg$ ← conversion

$v = 1{,}500$ mph $= 1{,}500 \times 1{,}600 = 2{,}400{,}000$ metres/h $= 2{,}400{,}000 \div 3{,}600 = 666.7$ m/s

$E_k = 0.5 \times m \times v^2$

$E_k = 0.5 \times 0.0105 \times 666.7^2$

$E_k = 2{,}333.4$ Joules ← units

Practice B: Calculating kinetic energy

1) A fighter jet travels at a velocity of 400 m/s. The pilot has a mass of 70 kg. Calculate the kinetic energy of the pilot.

2) An elephant of mass 1,800 kg runs at a constant speed of 3.5 m/s. How much kinetic energy does it have?

3) In 2016, Cate Campbell set the Olympic record for the women's 100 m freestyle with a time of 52.71 s. If Cate's mass was 74 kg, how much was her kinetic energy during the race? You should assume she swims at a constant speed.

4) A 4.2 g bullet travels at 1,700 mph. How much kinetic energy does it have?

5) A 3 mg snowflake falls at a terminal velocity of 3 m/s. What is its kinetic energy?

6) A rocket was launched from a space station, it weighed 50,000 kg and travelled at 3 km/h. What was its kinetic energy?

Assessment B: Calculating kinetic energy

A bullet with a mass of 80g is travelling at 950 m/s. What is its kinetic energy?

A	38 J
B	36.1 MJ
C	36.1 kJ
D	72.2 kJ

Objective C: Calculating mass and velocity.

Worked example 1

Serena Williams serves a tennis ball at a velocity of 60 m/s, and gives it 90 J of kinetic energy. Calculate the mass of the tennis ball.

$E_k = 90$ Joules
$v = 60$ m/s

$E_k = 0.5 \times m \times v^2$
$m = E_k \div (0.5 \times v^2)$ ← transformation

Study tip
Remember to re-arrange the equation!

$m = 90 \div (0.5 \times 60^2)$
$m = 0.05$ kg ← units

Worked example 2

A car of mass 800 kg is travelling with a kinetic energy of 1.44 MJ. Calculate its velocity.

$m = 800$ kg
$E_k = 1.44$ MJ $= 1{,}440{,}000$ J ← conversion

$E_k = 0.5 \times m \times v^2$
$v = \sqrt{(E_k \div 0.5m)}$ ← transformation

$v = \sqrt{(1{,}440{,}000 \div 400)}$
$v = 60$ m/s

Practice C: Calculating mass and velocity.

1) A car travelling at 10 m/s has 75 kJ of KE. Calculate the car's mass.

2) A bullet was fired from a gun. The bullet had a mass of 50g and the kinetic energy of the bullet was 25 kJ. How fast did it go?

3) A truck carrying heavy equipment travelled at 40 m/s and had a kinetic energy of 9 MJ, what was its mass?

4) A man started out with 1 kJ of kinetic energy and a mass of 100 kg. He then increased his kinetic energy by 100%. What was his speed after that?

5) An eagle flying at a constant 120 km/h and has kinetic energy of 2,800 J. What is the mass of the eagle?

Assessment C: Calculating mass and velocity.

A mosquito has a mass of 5 mg. Given that its kinetic energy is 0.8 mJ, how far will it travel in one hour?

A	34 m
B	2 km
C	19.2 m
D	1 km

Tutorial 4: Gravitational potential energy

Keywords: potential energy, mass, height, gravitational field strength

Objectives:

A) Define gravitational potential energy
B) Calculate gravitational potential energy, mass & height
C) Convert between gravitational potential energy and kinetic energy

Starter
Look at the picture above. Can you describe the energy transfers that occur during this rollercoaster ride?

When will the riders have the most gravitational potential energy? When will they have the least? What about their kinetic energy?

Objective A: Defining gravitational potential energy

Gravitational potential energy (GPE) is the energy an object has due to being raised above the ground.

$$E_p = mgh$$

Gravitational potential energy, E_p in joules (J)
Mass, m in kilograms (kg)
Gravitational field strength, g in newtons per kilogram (N/kg)
Height above the ground, h in metres (m)

Practice A: Defining gravitational potential energy

1. State the equation for gravitational potential energy, defining the symbols you use.

2. Write a sentence describing gravitational potential energy in words

3. Rank the following from low to high kinetic energy: a rhino balancing on a ball, an egg on a kitchen work top, a person in a hot air balloon.

4. Explain two ways that the gravitational potential energy of a pigeon could be increased.

Assessment A: Defining gravitational potential energy

Which statements are true, and which are false?

A	Gravitational potential energy is directly proportional to mass
B	In a mechanic's garage, a motorbike and a truck are both jacked 1 m above the floor. The motorbike stores more GPE than the truck.
C	Gravitational potential energy is stored by doing work against the gravitational force.
D	During an experiment, I lift a Newton meter 1 m above the earth. If I do the same experiment on the moon, I will store less GPE in the Newton meter.

Objective B: Calculate GPE, mass & height

Worked example 1: Finding GPE

A diving platform is 10 m above the ground. When an 80 kg diver climbs to the top of the platform, how much GPE does he acquire?

Solution

In the question we are given that the mass is 80 kg, and the height is 10 m. If no value is given, we can assume that the gravitational field strength on the earth is 10 N/kg.

Using these values in the equation for GPE:

$$GPE = 80\ x\ 10\ x\ 10 = 8{,}000$$

Worked example 2: Finding mass

The record for the highest hot air balloon flight is 21,027 m. At this height, the balloon had an estimated 735 MJ of GPE. What was the mass of the balloon?

Solution

Step 1: Rearrange the GPE equation to make mass the subject…

$$m = \frac{E_p}{gh}$$

Step 2: Substitute in our known values for GPE, h and g…

$$m = \frac{735\ 000\ 000}{10\ x\ 210127} = 3{,}500\ kg$$

Worked example 3: Finding height

At what height would the same hot air balloon have 50 kJ of GPe?

Solution

Step 1: Rearrange the GPE equation to make height the subject…

$$h = \frac{E_p}{mg}$$

Step 2: Substitute in our known values for GPE, h and g…

$$h = \frac{50\ 000}{3500\ x\ 10} = 1.4\ m$$

Practise B: Calculate GPE, mass & height

1. Mass = 4.87 kg, height = 54 cm. Calculate the GPE
2. Compare the gravitational potential energy of the motorbike and the truck from Part A. Take the truck's mass to be 5000 kg, and the bike's mass to be 120 kg.
3. If a 6 kg eagle in flight has 900 J of GPE, how high is it flying above the earth? A smaller bird would have to travel at twice this height to store as much GPE. What is the mass of the smaller bird?

Assessment B: Calculate GPE, mass & height

Which statements are true, and which are false?

A	A 65 kg bungee jumper stood over a 80 m drop has 52000 J of GPE
B	A 130,000 kg jet plane must reach an altitude of 1 km to gain 1.3 GJ of GPE
C	Tom Cruise hangs off the edge of a 1.2 km – high cliff face. If he has 81 000 J of GPE then he must weigh 75 kg.
D	A bowling ball has a mass of 7 kg. If the gravitational field strength on the moon is 1.6 N/kg, how much GPE is stored when it is lifted 0.5 m from the moon's surface?

Objective C: Convert between GPE and kinetic energy

Worked example 1:

Kris is at the top of a 5 m high slide. Assuming that all of her GPE is converted to KE, what will be her maximum speed when she reaches the bottom? Kris has a mass of 55 kg.

Solution

Step 1: Calculate Kris's GPE at the top of the slide:

$$GPE = 55\ x\ 10\ x\ 5 = 2750\ J$$

Step 2: As Kris slides down, her GPE is converted to KE. At the bottom of the slide, all her GPE will have been converted to KE, i.e. her KE equals 2750 J.

Next, rearrange the KE equation to find her speed:

$$v = \sqrt{\frac{2KE}{m}}$$

Step 2: Substitute our known values for m and KE:

$$v = \sqrt{\frac{2\ x\ 2750}{55}} = 10\ m/s$$

Study tip
Here we assumed that **all** of the GPE was converted to KE. However, in the real world some energy would be dissipated as heat, due to friction and air resistance. This means that Kris's true speed will be **less** than we have calculated here.

Worked example 2:

Roger Federer hits a tennis ball of mass 50 g directly upwards in the air, at a velocity of 25 m/s. What is the maximum possible height the ball could reach?

Study tip
Don't forget to convert grams into kilograms to use the KE equation!

Solution

Step 1: Calculate the ball's initial kinetic energy

$$KE = \frac{1}{2}\ x\ m\ x\ v^2 = 0.5\ x\ 0.05\ x\ 25^2 = 15.6\ J$$

Step 2: The maximum possible height that the ball could reach would be if all this KE was converted to GPE, i.e the GPE becomes 15.6 J.

Next, rearrange the GPE equation for height:

$$h = \frac{E_p}{mg}$$

Step 3: Substitute in the known values for GPE, mass, and gravitational field strength:

$$h = \frac{15.6}{0.05\ x\ 10} = 31.3\ m$$

Did you know?

We don't really **need** to know the mass to solve this problem!

We could have started by setting the KE and GPE equations equal to each other to get:

$$\frac{1}{2}mv^2 = mgh$$

Notice that we have m on both sides, so we can cancel out a factor of m to get:

$$\frac{1}{2}v^2 = gh$$

Then all we need to do is to rearrange this equation for the height…

$$h = \frac{v^2}{2g}$$

…and finally, put in our known values!

Practise C: Convert between GPE and kinetic energy

1. Dr Who chases a dangerous alien to the top of the Eiffel tower in Paris. If she were to drop her sonic screwdriver from this height, what is the maximum speed it could reach when it hits the floor? Ignore air resistance and assume that all the GPE is converted to KE. The Eiffel Tower is 300 m high, and the screwdriver has a mass of 113 grams.

2. A bullet of mass 11.3 g is fired directly up into the air with an initial KE of 3.6 kJ. What is the bullet's initial velocity? What is the maximum height the bullet could reach?

3. Felix Baumgartner was the first human being to travel faster than sound, without the aid of a vehicle! He achieved this by jumping out of a hot air balloon at a height of 39 km. His total mass, (including his special space suit) was 120 kg.

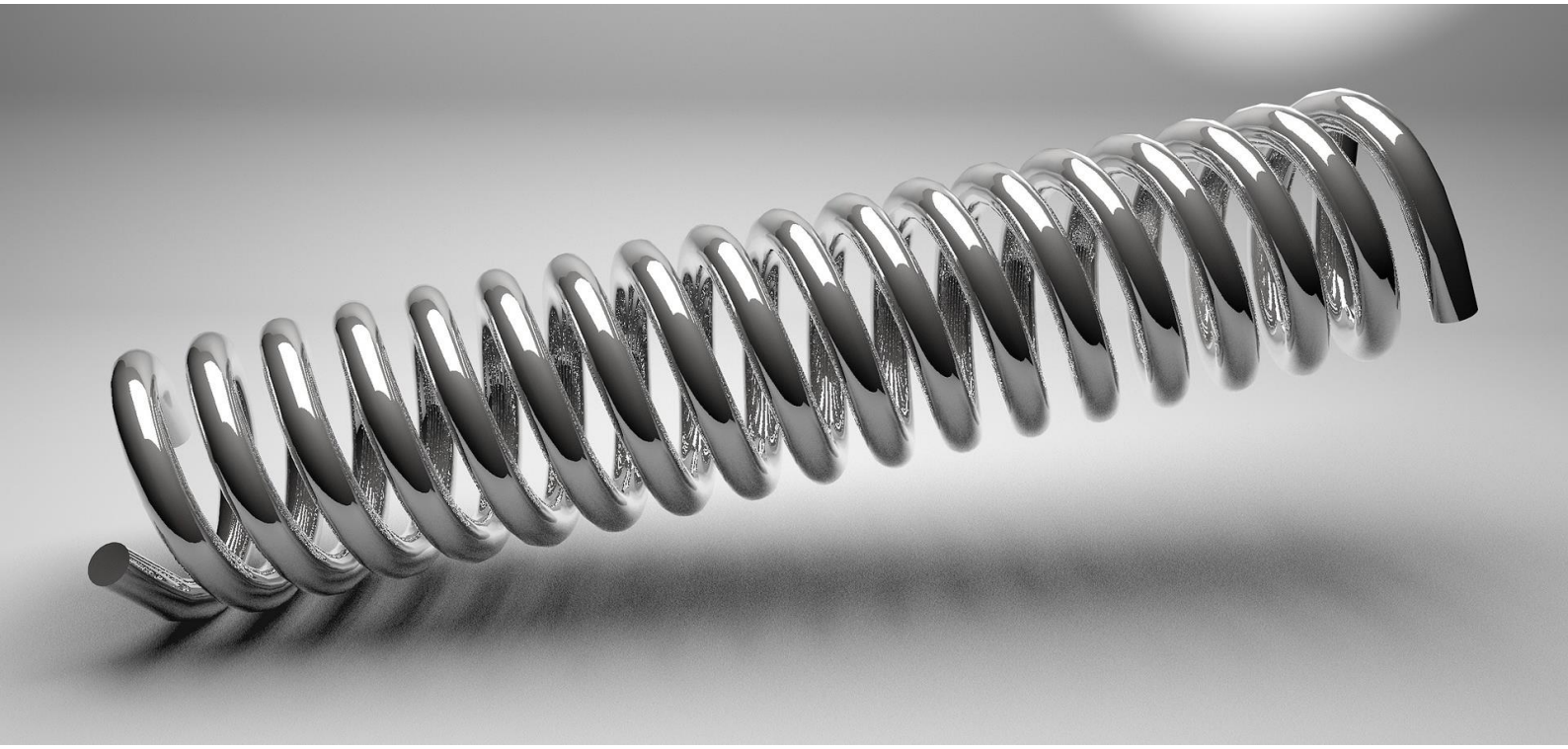
   How far did Felix fall before he broke the sound barrier? Sound travels at 343 m/s.

Assessment C: Convert between GPE and kinetic energy

An irresponsible tourist drops a penny of mass 2.5 g from the top of the Burj Khalifa in Dubai. The Burj Khalifa is 828 m high.

Which statements are true, and which are false?

A	The penny's GPE at the top of the Burj Khalifa is 20.7 kJ
B	The penny's GPE at the top of the Burj Khalifa is 20.7 J
C	The maximum velocity of the penny as it hits the ground is 16.5 km/s
D	The maximum velocity of the penny as it hits the ground is 0.129 km/s



Tutorial 5: Elastic potential energy

Keywords: spring constant, extension, joules.

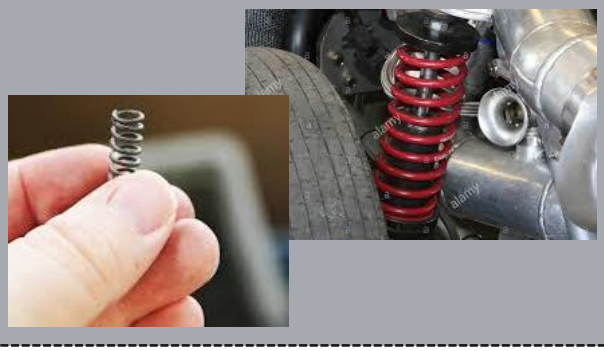
Objectives:

A) Define elastic potential energy
B) Calculate elastic potential energy
C) Convert between elastic potential and other forms of energy

Starter

Which of these springs has a larger spring constant:

a) Spring on a car's suspension.
b) Small (2cm) spring.



Objective A: Defining elastic potential energy

Elastic potential energy is the energy stored in a stretched, or compressed, spring or elastic material:

$$E_e = \frac{1}{2}ke^2$$

Elastic potential energy, E_e in joules (J)
Spring constant, k in newtons per metre (N/m)
Extension, e in metres (m)

The spring constant is a measure of how much force is needed to stretch/compress the object.

Practice A: Defining elastic potential energy

1) State the equation for elastic potential energy, defining the terms used.

2) Write a sentence defining elastic potential energy in words.

3) You join two springs together and hang a mass off the bottom of them. How does the extension of both springs compare to the extension of one?

4) Describe the energy changes that occur when a rubber band is stretched, let go, flies straight up into the air and then falls back down to the ground.

Assessment A: Defining elastic potential energy

Which statements are true, and which are false?

A	A spring constant of 5 Nm means that it takes 5 Newtons of force to stretch the spring by 1 metre.
B	$k = E_e/(0.5 \times e^2)$.
C	Elastic potential energy is directly proportional to the extension.
D	Spring constant has units of Nm, and extension has units of metres.

Objective B: Calculating elastic potential energy

Worked example 1

How much work must be done to compress a spring by 4.0 cm if the spring constant is 55 N/m.

$e = 4\ cm = 0.04\ m$
$k = 55\ N/m$ ← conversion

Study tip
Don't forget to convert non-standard units into standard units!

$E_e = 0.5 \times k \times e^2$

$E_e = 0.5 \times 55 \times 0.04^2$
$E_e = 0.044$ Joules ← units

Worked example 2

A coil spring on a car's suspension have a value of k = 64 kN/m. When the car strikes a bump the spring briefly stores 80 Joules of energy. How much does the spring compress?

$k = 64\ kN/m = 64{,}000\ N/m$ ← conversion
$E_e = 80$

$E_e = 0.5 \times k \times e^2 \rightarrow e = \sqrt{(E_e \div 0.5k)}$ ← transformation

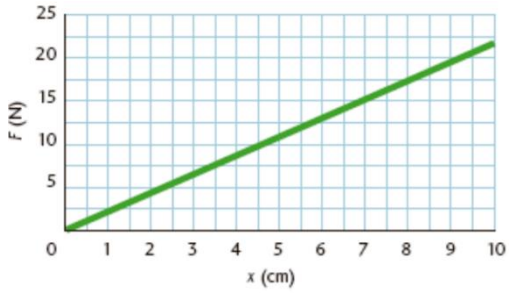
$e = \sqrt{(80 \div (0.5 \times 64{,}000))}$
$E_e = 0.05$ metres

Practice B: Calculating elastic potential energy

1. Solve for each unknown.
   a) A spring with k = 45 N/m is compressed by 13 cm. How much **energy** is stored?
   b) A spring with k = 520 N/m stores 7.04 J. How far is it **extended** from the equilibrium position?
   c) A spring, when compressed 20 cm from the equilibrium position, stores 26 J. What is the value of the **spring constant.**

2. A spring attached to a ceiling has a mass of 500 g suspended from it such that the spring stretches 4.0 cm. Calculate the **spring constant**. (g = 9.8 N/kg)

3. To the right is a graph of F versus e for an elastic spring. Determine:
   a) The spring constant.
   b) The spring's maximum amount of elastic potential energy.
   c) The change in elastic potential energy when the spring extends from 3 cm to 4 cm.



Assessment B: Calculating elastic potential energy

At maximum extension a bungee cord stores 2.0×10^6 J of energy. A 10-kg mass extends the bungee cord 1.3 m. What is the maximum extension of the bungee cord?

A	230 m
B	0.23 m
C	0.46 m
D	460 m

Objective C: Convert between elastic potential and other forms of energy

Worked example 1

An elastic band of spring constant 5 N/m and mass 2 g is stretched by 15 cm and shot directly up in the air. Calculate the maximum height that the elastic band reaches.

$e = 15\ cm = 0.15\ m$ ← conversion

$k = 5\ N/m$

Study tip
Don't forget to convert into standard units!

$E_e = 0.5 \times k \times e^2$

$E_e = 0.5 \times 5 \times 0.15^2$

$E_e = 0.056$ Joules

The EPE is all converted into GPE; therefore the GPE is also 2×10^{-6} Joules.

$E_p = m \times g \times h$

$m = 2\ g = 0.002\ kg$

$g = 9.8\ N/kg$

$E_p = 0.056$ Joules

$h = E_p \div (m \times g)$ ← transformation

$h = 0.056 \div (0.002 \times 9.8)$

$h = 2.9$ metres ← units

Practice C: Convert between elastic potential and other forms of energy

1. An arrow of mass 300g is shot directly upwards by a bow of spring constant 2000 N/m, that is extended by a distance of 20 cm. Calculate:
   a) The maximum elastic potential energy stored by the bow.
   b) The initial velocity of the arrow.
   c) The maximum height that the arrow reaches. (g = 9.8 N/kg)

2. A student stretches (by 20 cm) an elastic band of spring constant 20 N/m and mass 5g directly at the teacher. The student gets 10 minutes of detention for each metre/second of velocity that it hits the teacher with. How long is the student's detention?

Assessment C: Convert between elastic potential and other forms of energy

A boy bounces on a pogo stick (total mass 40 kg) of spring constant 3200 N/m. If the pogo stick is compressed by 50 cm, and all elastic potential energy is converted into gravitational potential energy; how high does the boy reach?

A	1.02 m
B	1002 m
C	2.04 m
D	0.102 m

Tutorial 6: Final Assessment

Keywords: kinetic, energy, mass, velocity

In this tutorial we will check your understanding of energy, and identify any areas for improvement.

Remember...

- Attempt every question
- Always show your working
- Check your calculations
- Give units with every numerical answer
- Look at the marks available for each question to help you plan your time.

Good luck!

Tutorial 7 - Feedback

What is the Purpose of Tutorial 6?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well...	What I could have improved on...
•	•
•	•
•	•

My target for future work is...

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Notes

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Notes

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