Physics (Energy)

Key Stage 4 Revision Programme

Pupil Name	Name
Handbook Designed by	Dr. S. Sharma

Timetable and Assignment Submission

Timetable – Tutorials

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

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
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Activity n

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Reflection on feedback

Course Rationale

10,000 hours is a long time. You've heard this number described as the amount of time needed to achieve "greatness" in a given skill or area of expertise. It comes from Malcolm Gladwell's popular 2008 book, *Outliers: The Story of Success*, where he cites 10,000 hours as the "magic number" of practice time required to achieve true mastery in a given domain. He gives examples of people like Bill Gates and the Beatles, who spent large amounts of time honing their craft before achieving the great successes we know them for.

In this course students will engage in focused, intense practice sessions, but usually only for an hour at a time. The aim of this course is to make students experts in the chosen topic through deliberate practise.

Subject Vocabulary

Word	Definition	In a sentence
Energy	the property of matter and radiation which is manifest as a capacity to perform work (such as causing motion or the interaction of molecules): *a collision in which no energy is transferred*.	
Joule	the SI unit of work or energy, equal to the work done by a force of one newton when its point of application moves one metre in the direction of action of the force, equivalent to one 3600th of a watt-hour.	
Watt	the SI unit of power, equivalent to one joule per second, corresponding to the rate of consumption of energy in an electric circuit where the potential difference is one volt and the current one ampere.	

Tutorial 1 – Kinetic Energy and Gravitational Potential Energy

What is the Purpose of Tutorial 1?

- To understand the definition of kinetic and gravitational potential energy
- To be able to solve problems related to EK and GPE
- To be able to convert units and solve exam questions

1. Kinetic and Gravitational Potential Energy

Keywords: mass, velocity, Gravity

Objectives this tutorial:

A) Defining Gravitational Potential Energy and Kinetic Energy
B) Calculating Gravitational Potential Energy and Kinetic Energy

Starter:

1.Name the nine different types of energies

2. Name the ways energy can be transferred

Objective A: Defining GPE, KE

The energy stored in a moving object depends on its mass and speed.

The gravitational potential energy of an object increases when it moves up because work is done on it to overcome the force of gravity.

Kinetic Energy = 0.5 x mass x speed²
Potential (J) (kg) (N/kg) (m/s)² (J)

gravitational = mass x field strength x height
(kg) (N) (m)

Practice A: Defining EK and GPE

1. The gravitational potential energy of an object _____ when it moves up because _____ is done on it to overcome the force of _____.

2. The energy stored in a _____ object depends on its _____ and _____.

3. List the different types of energy stores

4. State the equations to calculate EK and GPE

5. Change in gravitational Potential (J) = Weight (N) x height (m)

change in is this equation correct. If yes or no Why?

Assessment A:

Which statement is incorrect?

A	For an object, speed is equal to square root of the kinetic energy divided by mass.
B	GP $= \frac{m}{h} * field\ strength$.
C	An object travelling at constant speed changes direction. Its EK does not change
D	Mass has units of kg, speed has units of m/s and energy has units of Joules.

Objective B: Calculating Kinetic energy

Worked example 1
A wind up toy of mass 100 g has a speed of 0.05 m/s. Calculate the speed of the toy.

$m = 100\ g = 0.1\ kg$ ← conversion
$v = 0.05\ m/s$

$Ek = 0.5 \times m \times v^2$
$Ek = 0.5 \times 0.01 \times (0.05)(0.05)$
$Ek = 0.0000125\ J$

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

Worked example 2 ← units
The exhaust of a rocket expels 1×10^{-2} kg of gas at a speed of 20 km/s. What is the kinetic energy of the expelled gas?

$m = 1 \times 10^{-2}\ kg$
$v = 20\ km/s = 20{,}000\ m/s$

$Ek = 0.5 \times m \times v^2$
$Ek = 0.5 \times 1 \times 10^{-2} \times 20{,}000^2$
$Ek = 200{,}000{,}000\ J$

Worked example 3
An elevator of mass 300 kg moves upward at a speed of 1.5 m/s. The elevator then moves downward at a speed of 1.0 m/s. Calculate the difference Ek of the elevator when it is travelling (a) upward (b) downward.

Take upward as positive and downward as negative.

a) upward

$m = 300\ kg$
$v = +1.5\ m/s$

$Ek = 0.5 \times 300 \times 1.5 \times 1.5$
$ek = 337.5$ Joules

b) Downward

$m = 300\ kg$
$v = 1.0\ m/s$

$Ek = 0.5 \times 300 \times 1 \times 1$
$Ek = 150$ Joules

Practice B: Calculating kinetic energy

1) A jet plane travels at 220 m/s. The pilot has a mass of 75 kg. Calculate the kinetic enwrgy of the pilot.

2) A fan moves 0.5 kg of air. The air from the fan moves a distance of 1.5 m in 1 second. Calculate the kinetic energy of the air moved by the fan.

3) A cannon of mass 200 kg fires a cannon ball of mass 20 kg. The ball travels forward at 50 m/s and the cannon recoils at a speed of 5 m/s. Calculate the Ek of (a) the cannon (b) the cannon ball.

4) Assuming the Earth follows a circular orbit around the Sun, calculate the Ek of the Earth. Radius of Earth orbit: 1.50×10^{11} m. Period of orbit: 365.25 days. Mass of Earth: 5.98×10^{24} kg.

5) The propeller of a boat moves 150 kg of water backward at 10 m/s. The boat of mass 300 kg moves forward with a speed of 5 m/s. Calculate the EK of (a) the boat (b) the water moved by the propeller.

6) An oxygen molecule in air has a speed of 450 m/s. At what speed would a carbon dioxide molecule need to travel to have the same momentum as the oxygen molecule? Mass of oxygen molecule: 5.3×10^{-23} g. Mass of carbon dioxide molecule = 7.3×10^{-23} g.

Assessment B: Calculating Kinetic energy

A gas particle of mass 5×10^{-20} g strikes the wall of its container at a speed of 200 m/s and rebounds at the same speed. Calculate the kinetic energy of the particle before and after the collision. Assume the particle travels along the normal to the container wall.

	Before	After
A	1×10^{-17} kg m/s	1×10^{-17} kg m/s
B	1×10^{-17} kg m/s	-1×10^{-17} kg m/s
C	1×10^{-20} kg m/s	-1×10^{-20} kg m/s
D	1×10^{-20} kg m/s	1×10^{-20} kg m/s

Objective C: Calculating Gravitational potential energy (GPE)

Worked example 1
A glider of mass 1500 kg is atop a hill of height 25 m. Calculate the GPE

GPE = M x g X h

GPE = 1500 X 10 X 25

GPE = 375,000 Joules

Worked example 2

A car with a full tank of petrol has a mass of 2000 kg. The car drives at a constant speed of 20 m/s for a period of time and loses 5 kg of petrol. Comes to a halt on a hill 5 m above the ground, calculate its GPE.

GPE:

m = 2000 kg

v = 20 m/s

gpe = 1995 x 5 x 10 = 99,750 Joules

Worked example 3

A boulder of mass 5 kg is stationary on a hill 100 m high. The boulder rolls down the hill with a speed of 5 m/s. Calculate the GPE and Ek of the boulder.

GPE

m = 5 kg

h = 100

GPE = 100x 5 x5= 250 Joules

EK

m = 5 kg

v = 5 m/s

p = 0.5 x (5) x 5 x 5 = 62.5 joules

Practice C: Calculating GPE

1) A car of mass 1500 kg travelling at 10 m/s puts on the brakes and comes to a halt 20 m above the ground. Calculate the GPE of the car.

2) A snowball of mass 0.5 kg rolls down a hill at speed 2 m/s. As it rolls, the ball gains 0.1 kg of snow without changing speed and comes to rest 0.1m above the ground. Calculate the GEP and EK of the snowball.

3) A rocket fully loaded with fuel has a mass of 100,000 kg and takes off with speed 10 m/s. After a period, the rocket has burned 50,000 kg of fuel, and has a speed of 20 m/s. Calculate the change in EK of the rocket.

Assessment C: Calculating GPE

A ball of mass 0.5 kg falls and strikes the ground at velocity +3 m/s and comes to rest at a height of 1 m above the ground. Calculate the GPE of the ball.

Plenary: The photo shows a cue ball of mass m at rest. After being struck the cue ball has velocity v. Write a paragraph about this event in the context of this tutorial's objectives.

Tutorial 2 – Elastic energy

What is the Purpose of Tutorial 2?

- To define elastic energy
- Solve problems and calculate elastic energy
- To interpret graphs

2. Elastic energy

Keywords: momentum, mass, velocity, vector

Objectives this tutorial:

A) Defining Elastic energy

B) Calculating elastic energy

Starter: Write out the definition for elastic potential energy

Objective A: Defining momentum

EPE = (1/2)k.x^2

Where K is the spring constant n/m, and x is the displacement from equilibrium (m) (the natural rest length or shape of the elastic medium)

Elastic energy is measured in Joules.

Practice A: Defining Elastic energy

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

2) Elastic p_____ energy is the energy s_____ in an object when w____ is done on that object.

Assessment A: Defining Elastic energy

Which statement is incorrect?

A	Every object, has the same spring constant.
B	K $= 0.5 * epe/x2$.
C	Elastic spring Potential = 0.5 x constant x extension^2 Energy (J) (k) (m)^2

Objective B: Calculating Elastic energy

Worked example 1

A spring, which has a spring constant k = 7.50 N/m, has been stretched 0.40 m from its equilibrium position. What is the potential energy now stored in the spring?

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

Elastic spring
Potential = 0.5 x constant x extension^2
Energy (J) (k) (m)^2

$0.5 \times 7.5 \times 0.40^2 = 0.6$ J ← units

Worked example 2

An elevator of mass 300 kg moves upward at a speed of 1.5 m/s. The elevator then moves downward at a speed of 1.0 m/s. Calculate the momentum of the elevator when it is travelling (a) upward (b) downward.

Calculate elastic potential energy in a trampoline spring with a spring constant of 5000N/m that has stretched 12cm.

$0.5 \times 5000 \times 0.12^2 = 36$J

Practice B: Calculating elastic energy

1) A spring with a spring constant k = 800 N/m has been compressed, and 196 J of potential energy is stored. What distance from equilibrium has the spring been compressed?

2) Alex jumps into the car and the spring suspension compresses by 2cm. Jack hits the car with a force of 80N directly above one spring. What is the spring constant of that spring?

3) Ethan then jumps into the middle of the car and his force is evenly spread across the 4 suspension springs attached to each wheel. He hits the car with a force of 100N. How far does each spring compress by?

4) How much energy is stored in this stretched elastic band when the extension is 30 cm? *(convert units)*

4) A spring has a spring constant of 7.5 N/m. What force is needed to make the spring extend the following distances? Assume the spring does not pass its elastic limit.
0.1 m
0.2 m
30 cm

5) A spring has a spring constant of 20 N/m. How far will it extend when the following forces are applied? Assume the spring does not pass its elastic limit.
10 N
50 N
0.2 kN

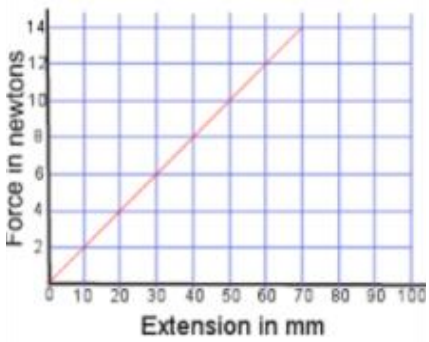
Assessment B: Calculating Spring constant

•Complete the table: *(Display the correct significant figures)*

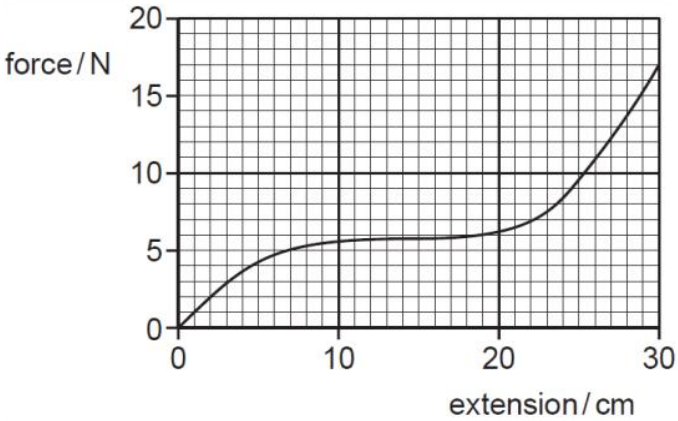
Elastic Potential Energy / J	Stiffness Constant / N/m	Extension / m
	0.100 k	0.020
	3.0	1.00
45 M	10 M	
85	525	
	0.55 G	25 µ
	2.5 T	90 n

Objective B: Calculating elastic energy Graphical methods

Calculate the elastic potential energy stored in the spring (see graph) when its extension is 70mm. *(convert units)*

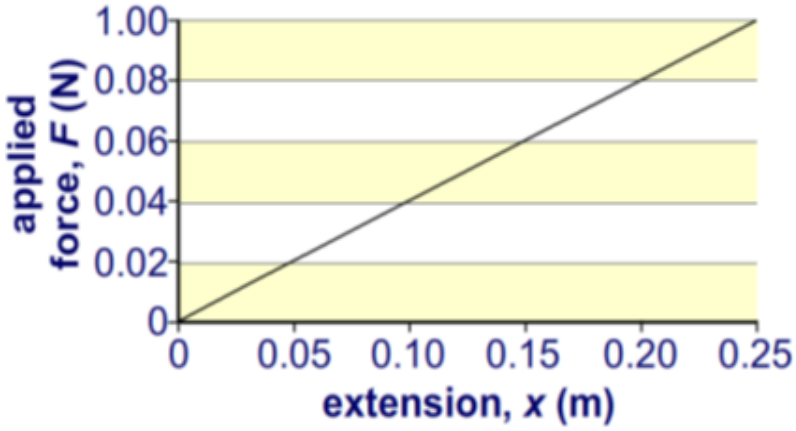


3) How much energy is stored in this stretched elastic band when the extension is 30 cm? *(convert units)*

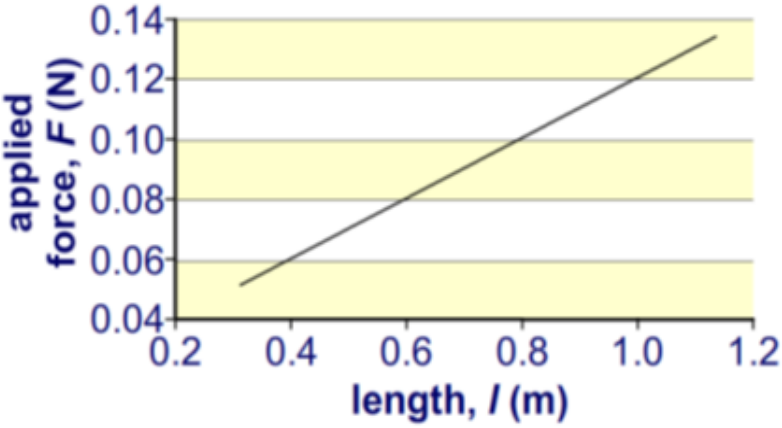


4) The following force against extension graphs were obtained for two springs. Use the graphs to find their spring constant.

a.



b.



Tutorial 3 – Power and Work done

3. Power

Keywords: power, work done, time

Objectives this tutorial:

A) Define Power and work done

B) Calculating Power and work done

Starter:

1. State the law of conservation of energy

2. Write the equations for Ek, GPE and Ee.

Objective A: Defining Power and Work done

Power (W) = $\frac{\text{energy (J) or work done}}{\text{time (s)}}$

Work done (J) = force (N) x distance (m)

Practice A: Defining Power and Work done

1. When an object is moved by f_____, work is done is done.

2. Work done to overcome f_____ is t_____ as energy to the t_____ energy stores of the objects that rub together and the s_____

3. Write out the definition for Power

4. Write out the formula for Power

Assessment A:

Which statement is incorrect?

A	Work done is measured in Joules
B	Power is measured in Watts
C	Power is work done X time
D	Work done = Force x distance

Objective B: Calculating work done

Worked example 1

Fred pushes the lawn mower 2 metres and applies a 5 N force, what work is Fred doing?

distance = d = 2 m
Force = 5 N

Work done = Force x distance

Work done = 5 x 2 = 10 joules ← units

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

Worked example 2

Emily does work of 6 J, and pushes with a force of 3 N, what distance does she travel?

Work done = 6 J
Force = 3 N

Work done = Force x distance

Distance = work done / force = 6/3 = 2 m

Worked example 3

An elevator of mass 300 kg moves upward at a speed of 1.5 m/s. Calculate the power of the elevator after 60 seconds.

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

$Ek = 0.5 \times 300 \times 1.5^2$

Ek = 225 joules

Power = energy/time = 225/60 = 3.75 W

Practice B: Calculating Work done

1. What is the work done if we apply a 1.2N force and we move 4 m in the direction of force?

2. What force is required to move 7 m if the work done is 9 J?

3. What force is required to move 7 m if the work done is 21 J?

4) What is the work done to a person if a force of 1.3N is applied and the person moves 6m?

5) What is the work done when a force of 5 N is applied to a ball and it moves 80 m?

6) What distance is moved if we have a 8N force and the work done is 90 J?

Assessment B: Calculating work done

A student carried out an investigation to see how much work they did to lift different masses. The results are shown below. Calculate the work done

Mass (kg)	Force (N)	Distance moved (M)	Work Done (J)
10		1.8	
20		1.8	
30		1.8	
40		1.8	
50		1.8	

Objective C: Calculating Power

Worked example 1

1. Calculate the **power** when pulling a heavy suitcase with a force of 10N along the floor for 20m, this takes 2.0 minutes (*change to seconds*).

Power = Work done / time = force x distance / time = 10 x 20 / 120 = 1/6 watts

Worked example 2

Calculate the power of a light bulb that uses 40J of electricity in 4 seconds.

Power:

E = 40 J

T = 4 s

Power = e/t = 40/4 = 10 W.

Worked example 3

Calculate the power of a train that uses 2kJ of chemical energy in 4 seconds.

Power

Power = Energy/ time

Power = 2 x 10e3 /4

Power = 500 Watts

Practice C: Calculating Power

1) Calculate the power of a sprinter if the sprinter has a weight of 800N and runs 100m in 12.2s.

2) Calculate the power of a car crusher if it pushes with a force of 6,000N. It covers a distance of 2m in 4s

3) Calculate the power of a lorry if the lorry has a weight of 1,000,000N and covers 10km in 20 minutes.

Assessment C: Calculating GPE

Maggie climbs up the stairs with some books, her weight is 500N and the books have a weight of 200N. She climbs a height of 20m. The power of her legs at 500W, how long does it take to climb the stairs?

Tutorial 4 – Energy transfer by heating and exam questions

What is the Purpose of Tutorial 4?

- Energy transfer by heating
- Exam questions practise

The energy transferred per second through an insulating material depends on:

- T_____ d_____ across the material
- T_____ of material
- T_____ c_____ of the material.

The rate of energy transfer from a house can be reduced by:

-
-
-
-
-

P2 Energy Transfer by Heating

Specific heat capacity

The specific heat capacity of a substance is the energy needed to raise the t_____ of _____kg by _____ °C.

Energy Transferred (J) = mass (kg) x specific heat capacity (J/kg/ °C) x temperature change (°C)

A pot is filled with 9kg of water at 10°C. Calculate how much heat energy would be needed to raise the temperature to 60°C. [specific heat capacity of water = 4200J/kg°C]

The greater the thermal conductivity of a material, the more e_____ per s_____ it transfers by c_____

Required Practical – insulating materials

Equipment:

- Various insulating materials
- 100ml measuring cylinder
- Kettle
- Thermometer
- Stopwatch
- 250ml Beaker

Method:

_____
_____
_____
_____
_____
_____
_____
_____

Dependent variable:
Independent variable:
Control variables:

-
-
-

Infrared – GCSE Physics only

All objects e_____ and a_____ infrared radiation.
The hotter the object is, the m_____ infrared radiation it e_____.
A perfect b_____ is a theoretical object that a_____ ALL the radiation that hits it and doesn't r_____ or t_____ any. As temperature increases, the w_____ of radiation d_____ (so white hot objects are hotter than red hot objects)
The temperature of an object will increase if it a_____ more radiation than it e_____.

Tutorial 5 – Final Assignment

Tutorial 6 - 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

Notes

Notes

Energy

Key Stage 4 Programme

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