Energy hacking

Key Stage 4 Programme

Pupil Name

Handbook Designed by

Timetable and Assignment Submission

Timetable – Tutorials

1			
2			
3			
4			
5			
6 (Feedback)			

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on	10 marks deducted
Plagiarism	
Extreme plagiarism	Automatic fail

The Brilliant Club KS4 Programme – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at AS-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Extreme plagiarism	Automatic fail

Name of PhD Tutor			
Title of Assignment			
Name of Pupil			
Name of School			
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 -	.
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 2 -	.
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 3 -	.
What you did in relation to this Key Learning Priority	How you could improve in the future
Resilience Comment	
How you showed learning resilience during the course	How you could build learning resilience in the future

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Course Rationale

Energy surrounds us. The sun provides light, our body generates heat, our car produces vibrations, as well as a plane wing or a bridge. People jogging on treadmills at the gym exert huge amount of power yet produce nothing. All this energy is lost to us, dissipated into the atmosphere.

What if we harnessed every tiny bit of energy surrounding us and converted it into electrical energy to reuse it?

The small amounts of generated electricity could then be used to supply low-power miniaturized electronic devices like sensors, or could be stored and added up to larger amount of energy to recharge our phones.

This is the principle of energy harvesting.

During these 6 tutorials, we will be research engineers designing an innovative structure for energy harvesting. We will study different techniques to generate electricity from the movement of the body, we will choose the best parameters for our generator, build it, test it and share our results with other scientists.

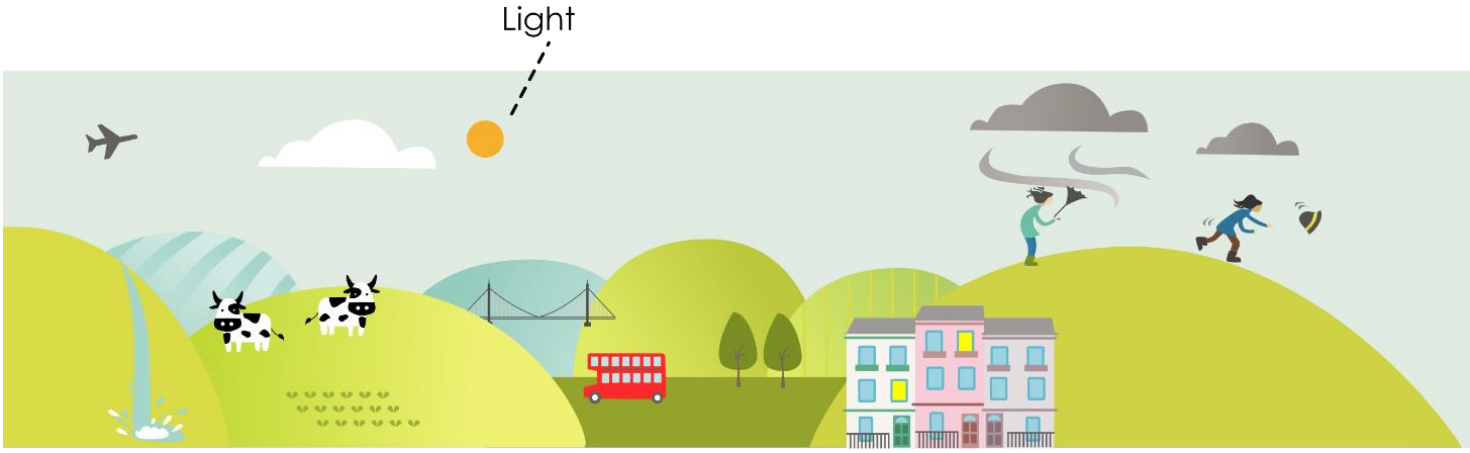
Mark Scheme Table

	Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Subject knowledge	Knowledge and Understanding	o All the steps undertaken in the process of designing and optimizing the harvester are clearly explained o Explanations show a good understanding of all the topics. o Scientific terms are defined and used accurately throughout	o Most of the steps undertaken in the process of designing and optimizing the harvester are clearly explained o Explanations show a good understanding of most of the topics o Scientific terms are used accurately but not always clearly defined.	o Some of the steps undertaken in the process of designing the harvester are clearly explained o Good understanding on some of the topics but occasional confusion on others. o Scientific terms are used mostly accurately with occasional confusion and often not defined.
Critical thinking	Research and Evidence	o Inclusion of rich sources of research findings, data or other sourced material and correctly referenced o Use equations to support claims/ideas, consistently clearly and convincingly o Data is effectively analysed and appropriate conclusions are reached	o Inclusion of adequate sources of research findings, data or other sourced material and mostly correctly referenced o Use equations to support claims/ideas, mostly clearly and convincingly o Data is analysed and the conclusions that are reached are mostly appropriate	o Inclusion of some sources of research findings, data, quotations or other sourced material o Use equations to support claims /ideas, at times clearly and convincingly o There is an attempt to analyse data and draw conclusions
	Critical Evaluation	o Moved beyond description to an assessment of the value of the work and the performances of the harvester	o Mostly description but some assessment of the value of the work and the performances of the harvester	o Only description with minimal assessment of the value of the work
	Structure and Presentation	o The introduction clearly outlines the general context of energy harvesting, some previous works, and the objectives of the report. o The conclusion summarises all the main point clearly and concisely o All calculations, formulas and methods are clearly structured, clear to follow and correct o All sources are referenced correctly using the agreed format	o The introduction adequately describes the general context of energy harvesting, some previous works, and the objectives of the report o The conclusion summarises most of the main points clearly o Calculations, formulas and methods are mostly structured, clear to follow and correct o Most sources are referenced correctly in an agreed format	o The introduction mentions the general context and the objectives of the report o The conclusion summarises some of the main points clearly o Some sources are referenced correctly in the agreed format with occasional errors o Calculations, formulas and methods are not always structured, clear to follow and correct
Written communication	Language and Style	o No spelling, grammar or punctuation errors o Units and significant figures are presented accurately throughout Accurate and consistent use of technical language and vocabulary	o Minimal spelling, grammar or punctuation errors o Units and significant figures are presented accurately throughout o Some attempts of using technical vocabulary, but not always accurate	o Some spelling, grammar or punctuation errors o Units and significant figures are presented accurately throughout with occasional errors o Use of simple language and vocabulary effectively but struggles to use technical language

Glossary of Keywords

Word	Definition	In a sentence
Energy harvester		
Sensor		
Specifications		
Prototype		
Modelling		
Optimisation		
Vibration frequency		
Vibration amplitude		
Electromechanical system		
Electromagnetic induction		
Piezoelectric material		
Stiffness		
Resonance		

Tutorial 1 – Introduction to our project and to Energy harvesting



What is the Purpose of Tutorial 1?

- To discover what is energy harvesting and a harvester
- To understand the applications of energy harvesting
- To know the steps involved when designing a harvester

Starter activity

Find and annotate on the picture above all the sources of energy

1. What is energy harvesting?

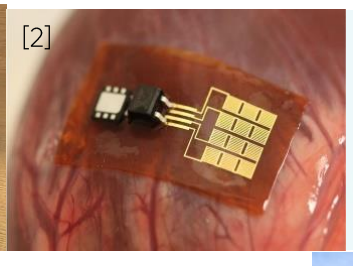
- Cite 3 examples of systems used to generate electricity from renewable energy sources:

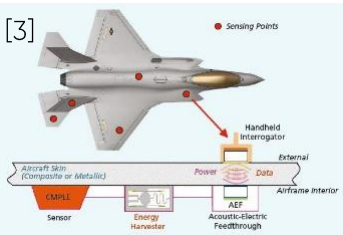
_____

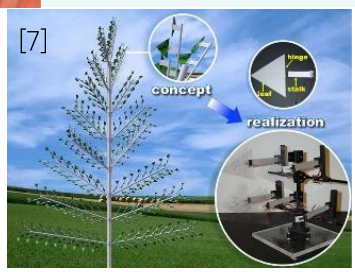
_____

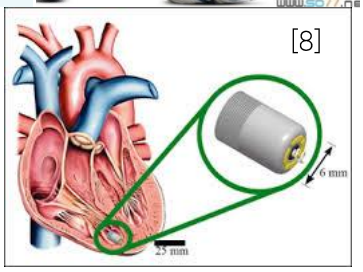
_____

- Look at these images of energy harvesters developed by researchers from several universities. In what aspects do they look different than the generators you cited above?









Energy harvesters are ...

An ***energy harvester*** *converts* _____ *into* _____

It is used to _____

2. Applications of energy harvesting

- Sensors

> A sensor is a device that _____ or _____ a physical property and records, indicate or responds to it.

Examples of sensors in everyday life:

Devices in which you find it	*Data measured*	*What provides energy?*

- Sensors Networks:

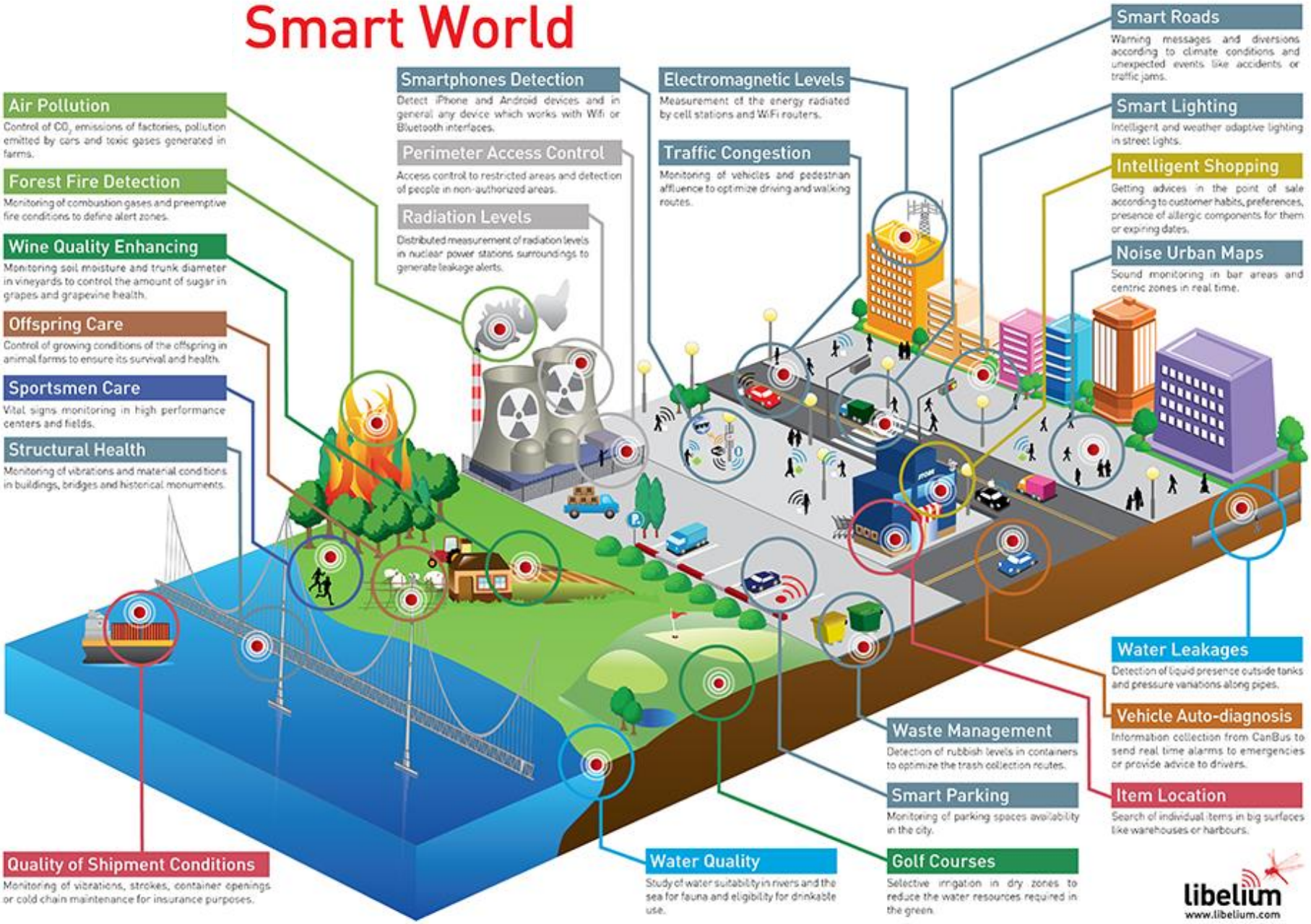
- "SMART DUST": What do that name and the picture evoke to you? What could it be used for?

What is measured by the sensors? Why?

Where could the energy harvester be located?

Which type of energy can be used to generate electricity?

Smart World


Air Pollution
Control of CO_2 emissions of factories, pollution emitted by cars and toxic gases generated in farms.
Forest Fire Detection
Monitoring of combustion gases and preemptive fire conditions to define alert zones.
Wine Quality Enhancing
Monitoring soil moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.
Offspring Care
Control of growing conditions of the offspring in animal farms to ensure its survival and health.
Sportsmen Care
Vital signs monitoring in high performance centers and fields.
Structural Health
Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.
Quality of Shipment Conditions
Monitoring of vibrations, strokes, container openings or cold chain maintenance for insurance purposes.
Smartphones Detection
Detect iPhone and Android devices and in general any device which works with Wifi or Bluetooth interfaces.
Perimeter Access Control
Access control to restricted areas and detection of people in non-authorized areas.
Radiation Levels
Distributed measurement of radiation levels in nuclear power stations surroundings to generate leakage alerts.
Electromagnetic Levels
Measurement of the energy radiated by cell stations and WiFi routers.
Traffic Congestion
Monitoring of vehicles and pedestrian affluence to optimize driving and walking routes.
Smart Roads
Warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.
Smart Lighting
Intelligent and weather adaptive lighting in street lights.
Intelligent Shopping
Getting advices in the point of sale according to customer habits, preferences, presence of allergic components for them or expiring dates.
Noise Urban Maps
Sound monitoring in bar areas and centric zones in real time.
Water Leakages
Detection of liquid presence outside tanks and pressure variations along pipes.
Vehicle Auto-diagnosis
Information collection from CanBus to send real time alarms to emergencies or provide advice to drivers.
Item Location
Search of individual items in big surfaces like warehouses or harbours.
Waste Management
Detection of rubbish levels in containers to optimize the trash collection routes.
Smart Parking
Monitoring of parking spaces availability in the city.
Water Quality
Study of water suitability in rivers and the sea for fauna and eligibility for drinkable use.
Golf Courses
Selective irrigation in dry zones to reduce the water resources required in the green.
libelium
www.libelium.com

- Other application: Energy pirating

[9]

3. Your energy harvester

- What would your energy harvester be used for?
- Which energy source would it use?

References :
[1] Instep Nanopwer
[2] C. Dagdeviren et al., 'Conformal piezoelectric energy harvesting and storage from motions of the heart, lung, and diaphragm', PNAS, 2014
[3] Scott Moss et al., 'Bi-axial Vibration Energy Harvesting', Department of Defense Report, 2013
[4] Qingguo Li et al., 'Development of a biomechanical energy harvester', Journal of NeuroEngineering and Rehabilitation, 2009
[5] Lei Zuo et al., 'Energy Harvesting from Rail Track for Transportation Safety and Monitoring', Project Report, 2014
[6] K Ylli, 'Energy harvesting from human motion: exploiting swing and shock excitations', Journal of Smart Materials and Structures, 2015
[7] William B. Hobbs, 'Tree-inspired piezoelectric energy harvesting', Journal of Fluids and structures, 2012
[8] Sebastien Boisseau et al, 'Toward pacemakers powered by heartbeats', Designlines Medical, 2012
[9] Damon Ahola, 'Hacking the orchestra of life', Masters Thesis, 2014

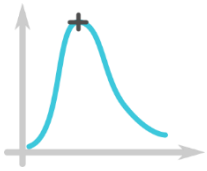
Our engineering project: design and fabrication of an energy harvester from ambient vibrations

Tutorial 2

- Defining the targets
- Listing the constraints and specifications

Tutorial 3

Tutorial 4



- Choosing the structure and materials constituting our harvester

- Describing our harvester behaviour with mathematical equations

- Finding the best dimensions

Tutorial 5

- Fabrication of the harvester

- Testing it

- Comparing its performances with what was calculated

Assessment/
Tutorial 6

- Sharing our results with the scientific community

- Getting feedback on our work from other specialists in the field

Baseline assessment

This baseline test is only to check your initial level of attainment in this subject area. It takes into account the fact that you may not be familiar with the subject area. It is designed to help you and your PhD tutor identify where you are at the start of the programme and to help you measure your progress along the way.

1. Cite examples of "mechanical energy" (as many as you can think of)

2. In your own words describe what is an "energy harvester"

3. Where can an energy harvester be used and what for? Give two examples of applications

4. Define in your own words the term "frequency" in a scientific context. What is its unit?

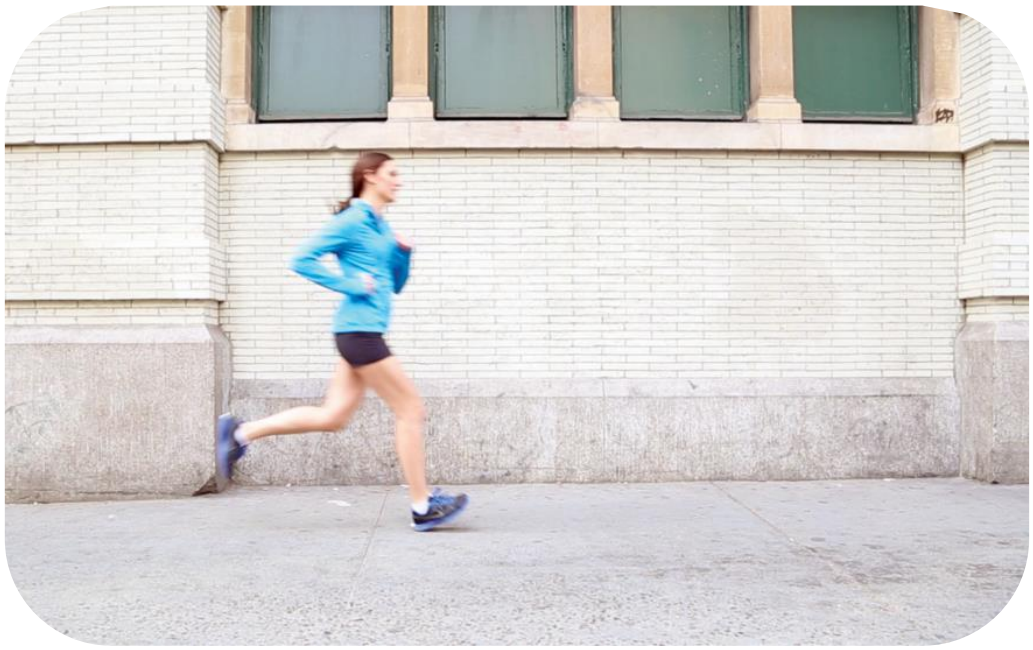
5. What is the relationship between the applied force on a spring and its elongation?

6. Considering two magnets. What do two poles of the same type do when they are brought close together?

7. In an electrical circuit, how do we measure the voltage across an electrical component?

8. If $a = -4\frac{b}{t}$ and $b = 2c$, what is a as a function of c?

Tutorial 2 – Writing the specifications for our energy harvester



What is the Purpose of Tutorial 2?

- To define our application, how much power we can get, how much we need
- To learn about vibration sources and their characteristics
- To write clear specifications taking into account constraints

Starter activity

List as many vibration sources in our everyday life as you can think of.

Number them from the strongest to the weakest (1 being the vibration source that can potentially have the largest energy)

1. Characteristic of vibrations

Vibration is the repetitive motion of an object around an equilibrium position.

The vibration of an object is always caused by an _____

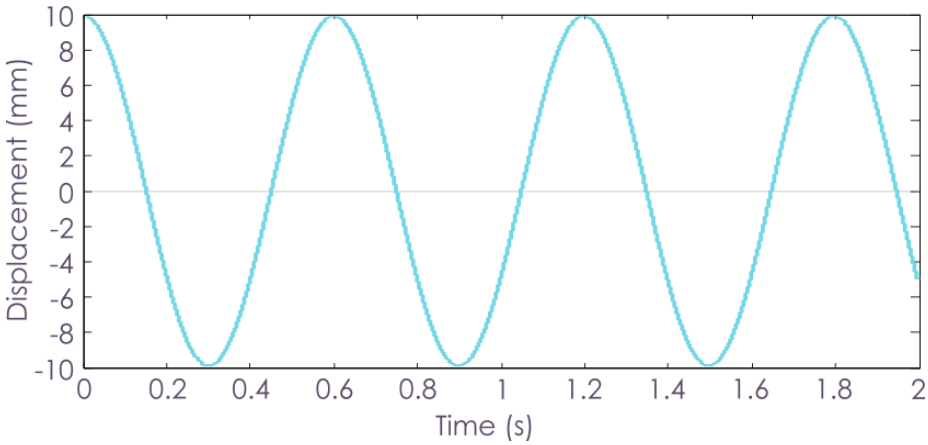
The ***frequency*** *of vibration is the number of to and fro movements made in each* _____ .

The amplitude of vibration is the size of the movement with respect from the equilibrium position

Frequency is measured in

Amplitude is measured in

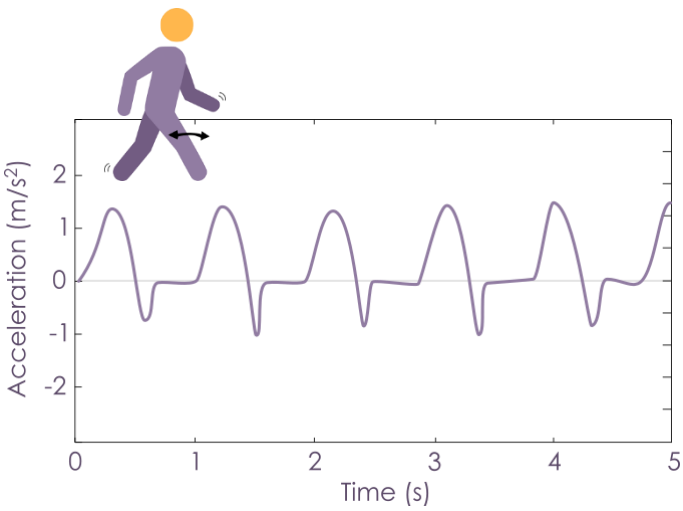
- For the following vibrations, calculate the frequency and amplitude.



Period of vibration: T =

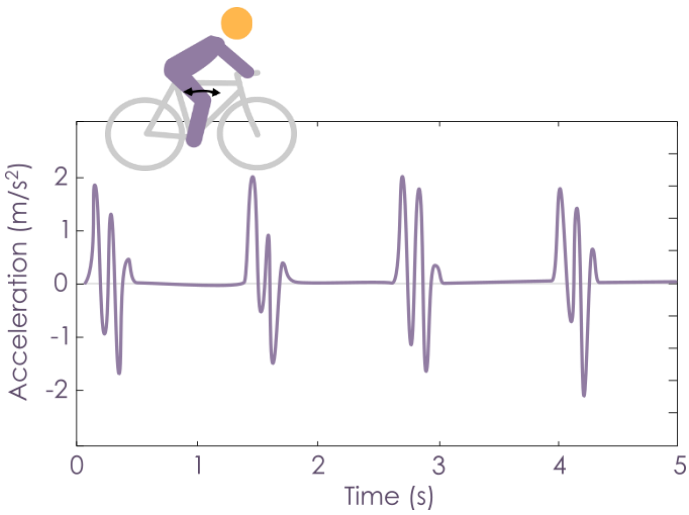
Amplitude of vibration: A =

Frequency of vibration: f = =



T = A =

f = =



T = A =

f = =

2. Vibration and energy

What is a strong vibration?

- Have a look at the two following videos:

Vibrations in AirAsia plane

Big Ben's pendulum

Which vibration has the largest amplitude?

plane Big Ben

Which vibration has the largest frequency?

plane Big Ben

Which vibration looks the more powerful?

plane Big Ben

*The potential output power is proportional to the **squared** amplitude of vibration*
*The potential output power is proportional to the **cube** of the frequency of vibration*

$$P \propto A^2 . f^3$$

3. Scientific article about energy harvesting

Have a look at the following scientific article, focusing on the 4 first pages, and the last 2.
It is a review article written by a very famous scientist in the field of energy harvesting.

- Use the highlighters to highlight:

in yellow:	information about the main author of the article (his name, university, biography, photo)
in pink:	references
in green:	information about several common vibration sources and their frequencies
in blue:	three techniques used in energy harvesters to convert energy

Notes:

Homework: Writing the specifications

Our project is about designing and fabricating an energy harvester generating electricity when we dance or run. The harvester will need to be attached to our body, at a place where the energy is large when dancing (/running). The generated electricity will be used to power a LED bracelet.

- Research online:

What is a LED?

How much voltage is used to light up a common LED?

How much current?

How much power will we need to light up one LED? (remember: power=voltage x current)

- List the specifications for your generator in the following page. After having fabricated the generator, we will come back to this list and tick the characteristics to check that the objectives are attained.

1 is related to the size (does your generator need to be small or big?)

2 is related to the weight (is it important? Should the harvester be heavy or light?)

3 is related to the power (how much power at least must the harvester generate?)

4 is related to the price of the harvester (do you want to fabricate something cheap, expensive?)

5, 6: any other special requirement (do you need the harvester to be rain proof? to look appealing? … ?)

1 ☐ _____

2 ☐ _____

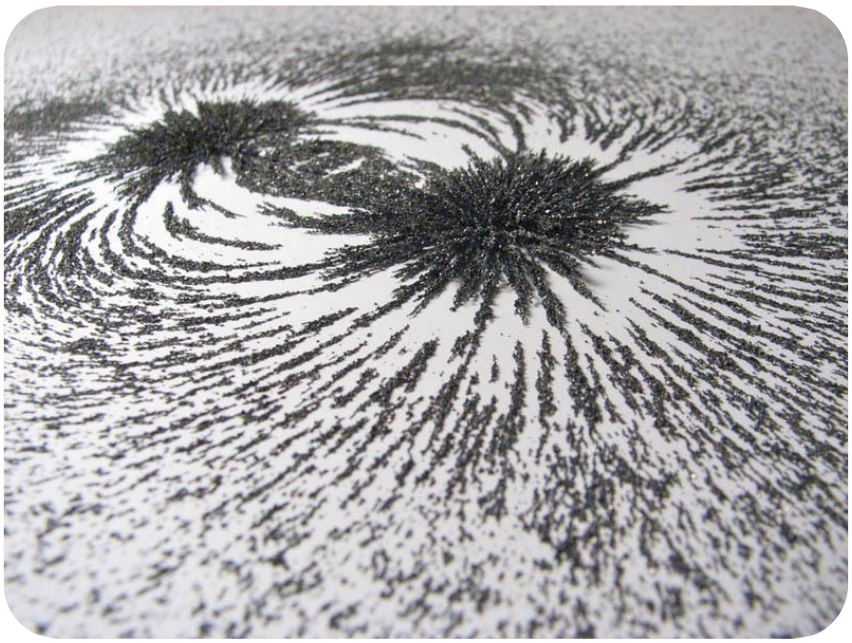
3 ☐ _____

4 ☐ _____

5 ☐ _____

6 ☐ _____

Tutorial 3 – Design and model of the electromechanical subsystem



What is the Purpose of Tutorial 3?

- To learn about several ways of converting mechanical energy into electrical energy
- To know electromagnetic induction
- To know what is a model and how to use it

Starter activity

What shows the picture?

What can you deduce from the picture?

What can you not deduce from the picture?

1. Magnetic field and flux

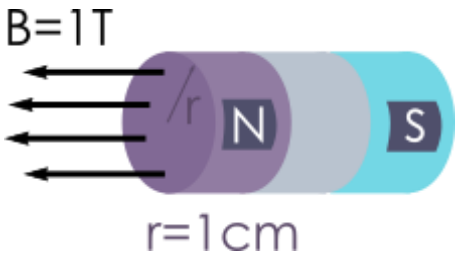
- Draw the magnetic field of the magnet

The magnetic field lines come out of the _____ pole and go into the _____ pole

*The **magnetic flux** is a measurement of the total magnetic field which passes through a given area*

$$\Phi = B \cdot A \qquad (1)$$

- Calculate the magnetic flux through the following surfaces



A =

B =

Φ =

A =

B =

Φ =

2. Electromagnetic induction, practical experimentation

Faraday's law of induction: *When a* _____ *moves close to a coil of wire,*

an electrical _____ *is generated at the coil's ends.*

- Using the coil and the magnets provided, find the different ways of generating electricity using electromagnetic induction

3. Electromagnetic induction, theoretical study

$$V = -N \cdot \frac{d\Phi}{dt} \qquad (2)$$

- Replace the magnetic flux by its expression given in equation (1), and rewrite the new equation for the voltage:

(3)

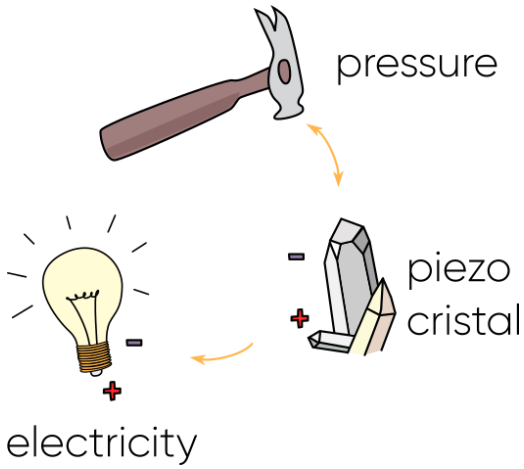
- Looking at the induction equation (3), identify the important parameters that we can play on to increase the generated voltage:

Conclusion on the optimisation of the subsystem:

Chosen magnet:

Chosen coil:

4. Discovery of piezoelectricity

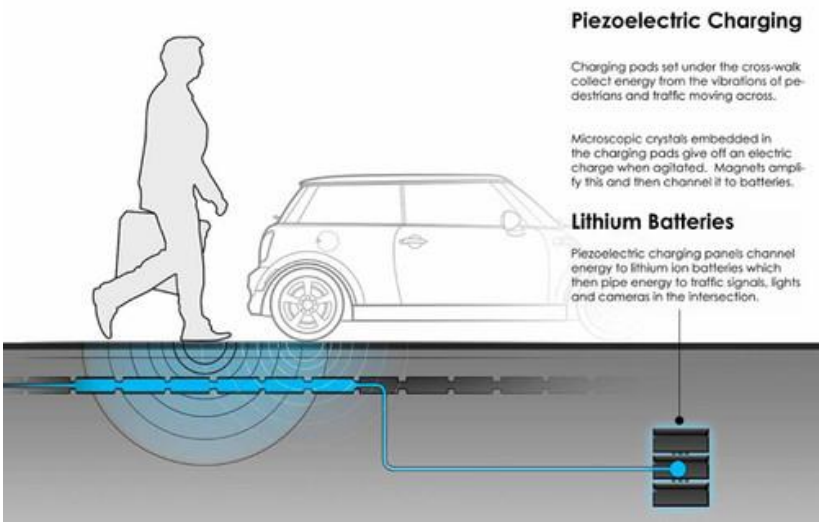


A piezoelectric material generates a _____ *when subjected to a mechanical* _____

This effect is reversible: it vibrates when subjected to a _____

- Test the piezoelectric film provided (from Mide Corporation)

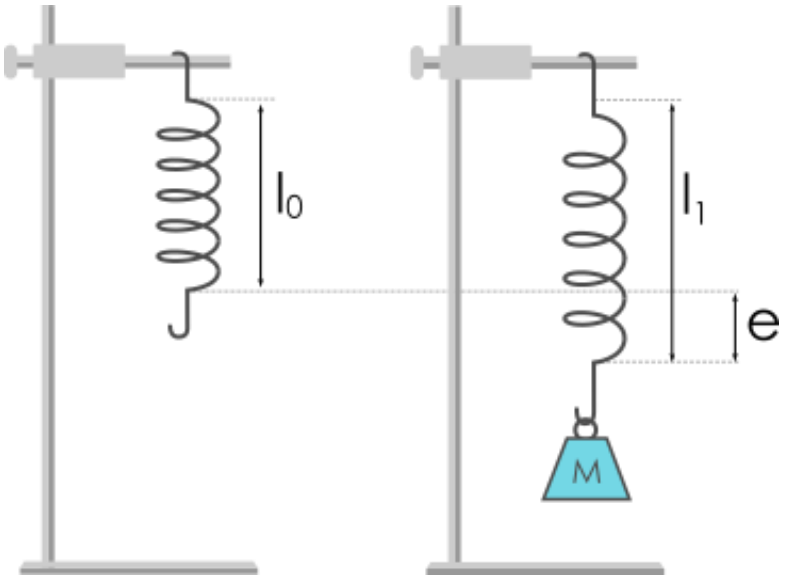
- Example of piezoelectric road:



Notes:

Homework: spring stiffness and Hooke's law

The force F needed to extend or compress a spring by some distance e is proportional to that distance. The coefficient is called the spring stiffness, and is written k. $F = k.e$



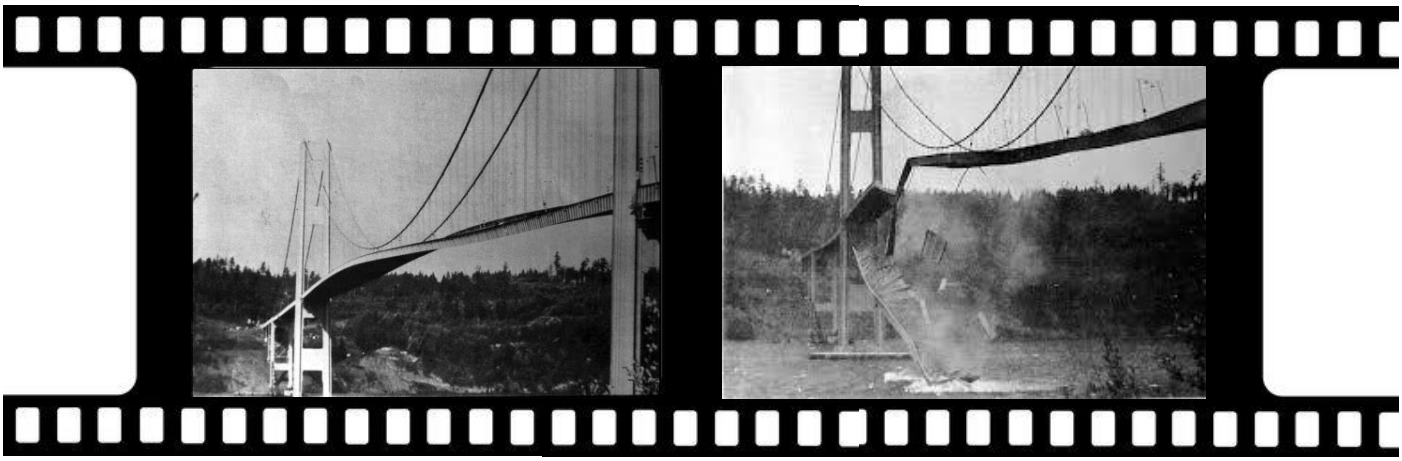
A spring has the initial length l_0= 5cm. A mass of M=100g is suspended at the free end and the new length is measured as l_1=6cm.
Fill in the table below with the values converted into the correct SI units (see the appendix).
Start with the green cells, then calculate the blue ones. Finally, using the definition of the stiffness above, calculate the spring stiffness k and report it in the orange cell.

l_0 (m)	M (kg)	F (N)	l_1 (m)	e (m)	k (N/m)

Another spring is now tested with the initial length of 4cm. A mass of 100g is placed on top of the spring, compressing it to the new length l_1=3cm. In the same way as before, complete the following table.

l_0 (m)	M (kg)	F (N)	l_1 (m)	e (m)	k (N/m)

Tutorial 4 – Design and model of the mechanical subsystem



What is the Purpose of Tutorial 4?

- To know what is mechanical resonance and how it could be useful in an energy harvester
- To understand what is the natural frequency of a mass spring system, and how to calculate it
- To choose the right spring for our energy harvester

Starter activity

What do you think happened to the bridge in the picture?

1. Spring and vibration

Attach a mass to a spring. Hold it from the other end, and start shaking it.

- What is giving the **excitation force**?

- Observe the mass and chose the right answer(s):

If you increase the excitation **amplitude,**

- ❑ the mass vibration amplitude increases
- ❑ the mass vibration amplitude decreases
- ❑ the mass vibration frequency increases

If you increase the excitation frequency,

- ❑ the mass vibration amplitude increases
- ❑ the mass vibration amplitude decreases
- ❑ the mass vibration frequency increases

2. Mechanical resonance

Resonance is the property of an object to vibrate at a _____ *when the excitation frequency matches the object natural frequency of vibration.*

The natural frequency of an object depends on _____ , _____ , _____ *of the object.*

At resonance, a weak excitation vibration can cause a _____ *vibration in the object.*

3. Natural frequency of a spring

Using the same spring as before, change the mass and find the natural frequency.

With a small mass:

The resonance frequency is

small large

With a large mass:

The resonance frequency is

small large

Back to the starter activity: Watch the video of the bridge and explain what happened

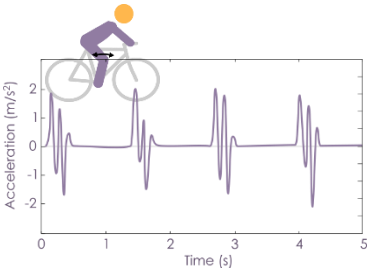
4. Calculation of the natural frequency of a system mass+spring

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

Spring	k (N/m)	Mass (kg)	f_0 (Hz)
Spring 1			
Spring 2			
Spring 3			
Spring 4			

5. Choosing the optimal spring for our application

For our chosen application (cf tutorial 2), determine which spring should be used if we want to have the maximum vibration amplitude for our magnet (=work at the resonance frequency).



Excitation frequency: f_{exc} =

Natural frequency of our system: f_0 =
Magnet mass: M =

Reminder: to get the maximum displacement amplitude inside our generator, the generator natural frequency must match the excitation frequency.

Conclusion on the optimisation of the subsystem:

Chosen spring :

Homework: Design your harvester

- Draw a schematic showing the structure of your harvester. It must include: a resonant system to amplify the vibration (=one or two springs), an electromechanical system to convert the vibration into electricity (=a magnet and a coil) any kind of support structure (a tube for instance, box, tape, etc)

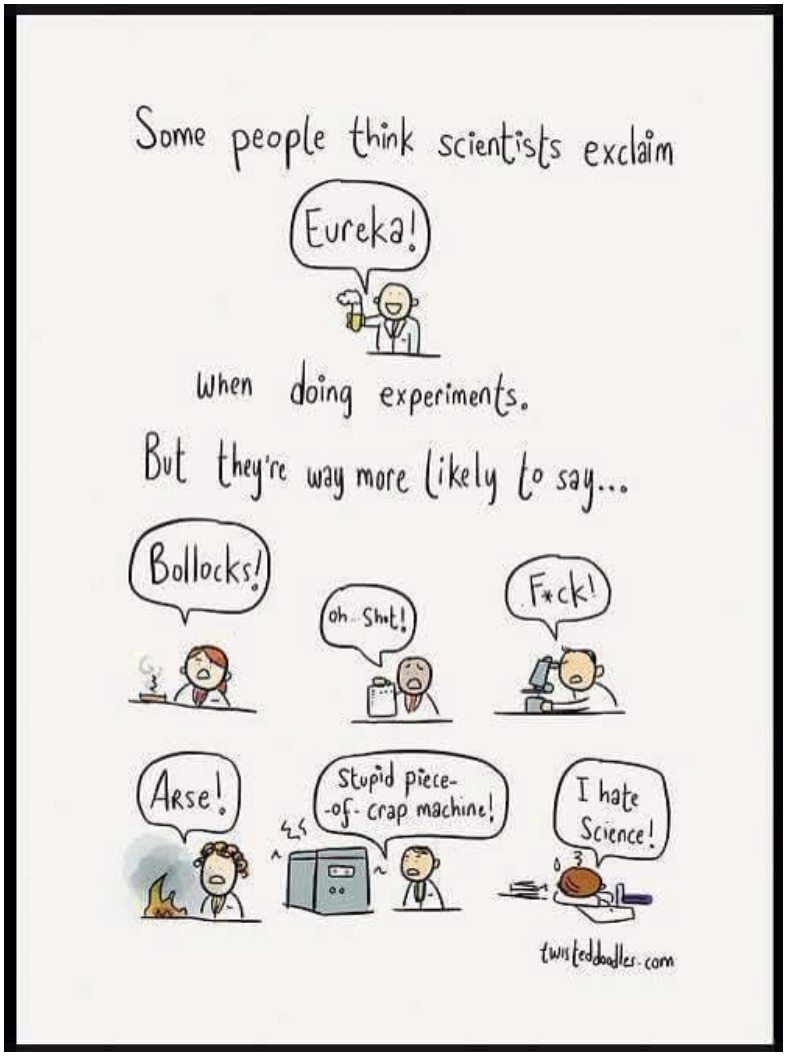
What is moving?

What is fixed?

Magnetic spring

- Instead of the two springs, you are given two more permanent magnets and a plastic tube that can be closed at one or both ends. Think of how you could use them to make a magnetic spring, and draw a schematic showing how we to use it for our generator:

Tutorial 5 – Fabrication and experimental characterisation of the harvester



What is the Purpose of Tutorial 5?

- Fabricate the harvester
- Learn how to do an experimental characterisation
- Measure the power output of the harvester

Starter activity

Why is it important for the scientists to do experiments? Write at least two reasons and discuss in pairs.

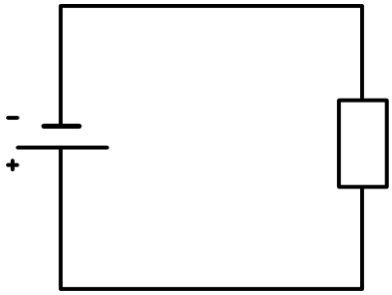
1. Fabrication

Using the magnet, springs and coils chosen in the previous tutorials, build the generator according to the drawing p. 30.

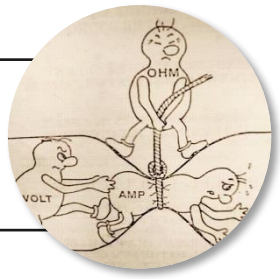
2. Testing the power generated by our harvester

- Complete the schematics with the following labels, and draw the voltmeter:

R	Resistance	Ohm (Ω)
i	Current flowing in the circuit	Ampere (A)
V	Voltage across the resistor	Volt (V)



Ohms' law shows the relationship between the _____ *flowing in a circuit, its* _____ *and the* _____ *across the component*



$$V = R \times I$$

The power generated by an energy harvester is usually defined as the power dissipated into a resistor connected at its ends.

$$P = V \times I$$

- Apply a vibration to your harvester and measure the generated voltage across the resistance. Calculate in each case the current flowing into the circuit, and the power generated by your harvester.

	R (Ω)	V (V)	I (A)	P (W)
Weak vibration				
Medium vibration				
Strong vibration				

3. Testing with the LED

◆ Connect one or several LEDs to the generator's ends instead of the resistor. How many can you light up with your generator?

4. Validation of the prototype

◆ Go back to the specifications established at the end of Tutorial 2. Check that your generator meets all the requirements.

◆ Reflect on your work, on the performances of your harvester. How could you improve it? (to make it smaller, to get more power out of it, to make it lighter ...)

Final assessment: share your work with the scientific community!

When researchers have interesting findings, they share it with other scientists by writing articles published in scientific journals. The publication of the results of research is an essential part of the researcher work. A journal article should describe the choices made, the calculations done and the experiments performed. They must supply enough details (about the material used, sizes, equipment used to do the tests), so that an independent researcher could repeat the experiment or calculation to verify the results.

- Write a journal paper recapitulating your work, the studies you have made, the harvester you have fabricated and your conclusions. Use the template provided, and take example from the paper read during the second Tutorial. Fill in all the sections with your own work and findings during the past 5 tutorials. Max 2000 words.

Article Title:
Change it and replace it by your own title, or leave it like that.

Name of the authors:
Add your name in first as you are the main author. The supervisor's name comes last.

Affiliation:
Specify which school or University you come from.

Abstract:
The abstract gives a short overview of the work presented in the article. Three or four sentences are enough.

Keywords:
Give 3 or 4 important words related to the work. They are used to facilitate online search of articles.

Introduction:
Must be structured as follow:

- General context (what is energy harvesting, what for?),
- What has already been done in the field (give examples of energy harvesters developed by other researchers, and reference them correctly),
- Objective of your work
- Outline of the article.

Specification and constraints:
This section presents to the reader the application that you have chosen, then details your objectives and the specifications for the design of your harvester.

Design and optimisation:
This section reports on all the choices made during the design process of the harvester. Each choice must be explained and if possible supported by equations or reference to a related article. Describe the structure you have chosen for your harvester, what technology you have used (electromagnetic induction and mechanical resonance), why, and how they are used, what dimensions/materials. You should include any equation that has helped you and explain how they were helpful. You can also include schematics.

Experimental validation:
This section describes the fabrication of the harvester and the tests done to evaluate its performances. You can include pictures of the harvester, schematics showing how you proceeded to do the tests, and detailed information about the size, materials, assembly of the harvester as well as all the results that you got.

Conclusion:
One or two sentences to sum up what you did during the 6 tutorials. You can also add a reflection on what could be improved and any idea for further work on that.

Reference:
This is the list of all the references you have used in the article. They must be numbered. The format is explained in appendix 1, p38.

Tutorial 6 – Feedback tutorial

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?
• • •	• • •

Appendixes

1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. A marker in your assignment: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. Bibliography: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.
    a. Websites – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

       E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. Books – Author, date published, title of book (in italics), pages where the information came from.

       E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. Articles – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

       E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

2 – Using the VLE

VLE username	
VLE password	

Please remember the following key details…

- You are able log into the VLE either through the link on our website (www.thebrilliantclub.org) or going directly to the VLE site at (https://portal.thebrilliantclub.org/sign-in).
- Please update your profile with your full name and email address- this will allow you to retrieve forgotten passwords or usernames
- If you forget your log-in details you can request them to be emailed to you by clicking the link on the VLE home page. (If you are still having problems you can email: schools@thebrilliantclub.org)

What is the VLE?

The VLE is a virtual learning environment for all pupils on Uni Pathways it is used for:

- messaging your tutor
- submitting homework
- submitting your final assignment
- accessing resources for your tutorials
- finding out more information about university and careers

How should I use the VLE?

The VLE is a professional academic environment in which pupils are able to message their PhD Tutor. Here are a few things to consider:

- Ensure you keep a professional tone in the messages you send to your tutors.
- Ensure you always reply to your tutors in a timely manner.
- Thank your tutor for the effort they are putting in to give you your feedback etc.
- Submit all homework to your tutor on time.

IMPORTANT: Final assignment

- When you submit your final assignment, please remember that you need to do so through the 'My Activities' tab and not as an attachment to a message.

3 – The SI units (International System of Units)

The SI unit system is a coherent system of units of measurement built on seven base units. It is the most widely used unit system, especially among the scientific community.

Quantity name	SI unit name	Si unit symbol	Other units, non-SI
length	metre	m	yard, inch, foot...
mass	kilogram	kg	ounce, pound...
time	second	s	
electric voltage	Volt	V	
power	Watt	W	
force	Newton	N	
magnetic field	Tesla	T	

Prefixes

Common multiples

Prefix name	Prefix symbol	Factor	Example
deca	da	x 10	1 daN = 10 N
hecto	h	x 10^2	1 hm = 100m
kilo	k	x 10^3	1 kg = 1000g
megq	M	x 10^4	1 MW = 10,000 W
giga	G	x 10^5	1 GW = 100,000 W

Common fractions

Prefix name	Prefix symbol	Factor	Example
deci	d	x 10^{-1}	1 dL = 0.1 L
centi	c	x 10^{-2}	1 cm = 0.01 m
milli	m	x 10^{-3}	1 ms = 0.001 s
micro	µ	x 10^{-4}	1 µg = 0.0001 g
nano	n	x 10^{-5}	1 nm = 0.00001 m

Notes

Notes

Energy hacking

Key Stage 4 Programme

researchersinschools.org