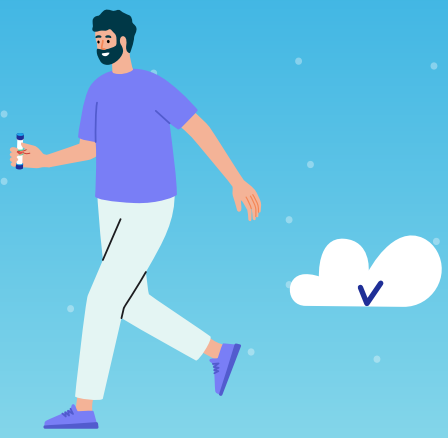
Topic 1

Energy Harvesting from Walking



Learning Objectives

Energy regeneration plays a key role in sustainable development in the future. In this topic, we will explore how to make use of scientific knowledge and innovative technology to harvest energy from walking through the following activities:

Activity I
Energy converter - Linear Electromagnetic Generator (LEG)

Activity II
Design and make LEG

Activity III
Real world application - Energy harvesting!

Green transportation pyramid

The Green Transportation Pyramid is a hierarchy of sustainable transportation options, with the most eco-friendly modes at the top and the least eco-friendly at the bottom.

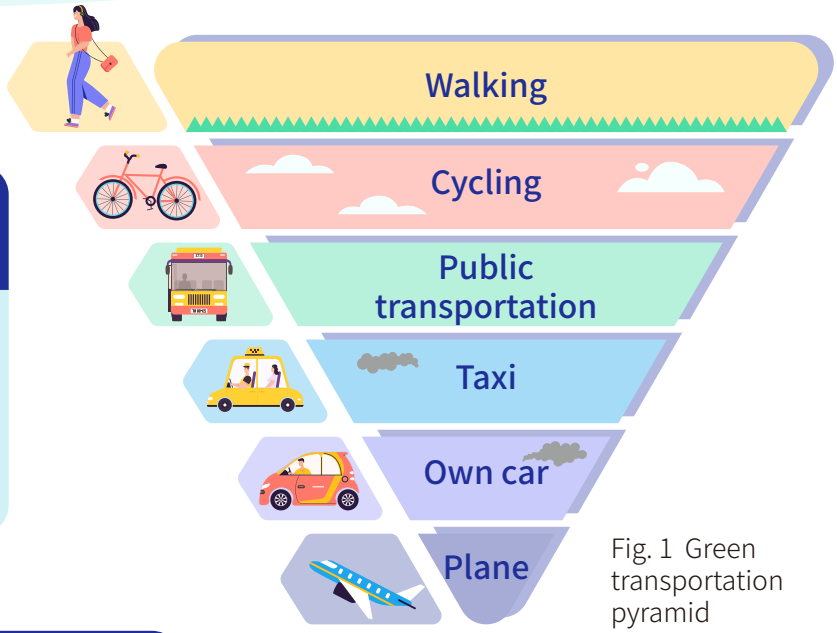
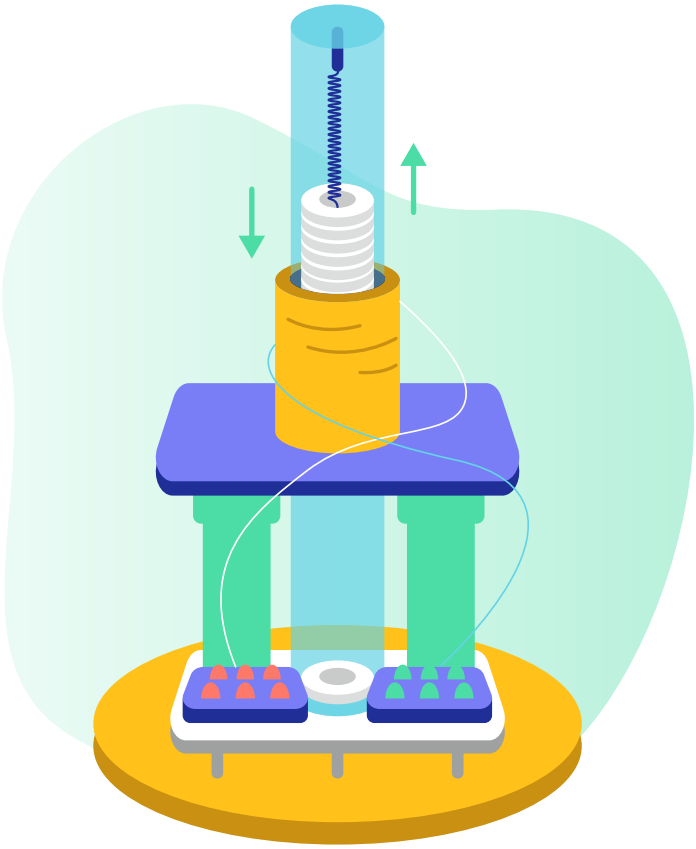


Fig. 1 Green transportation pyramid

Energy harvesting from walking

Walking is not only the most eco-friendly mode of transportation, but also a good way to generate useful energy. The bodily movement in walking generates *kinetic energy in the form of vibration* (vibration energy) which, however, is usually wasted. The "wasted" vibration energy can be harvested and converted to useful energy using an energy converter, e.g. LEG.

Activity I
Energy converter - Linear Electromagnetic Generator (LEG)



Introduction

In this activity, we will study the energy conversion process of LEG.

Watch the video below and answer the following questions.

Video 1

Questions

1 In this activity, energy is converted from one form to another. Write down the energy conversion process when the LEG is shaken.

Kinetic energy of the magnet ▶ _____ ▶ _____

2 The LEDs attached to the LEG light up without battery. A student suggested that the LEG is a source of "free energy" and can resolve the energy crisis. Do you agree with the student? Explain briefly.

_____

Conclusion

Energy can neither be _____ nor _____ ,

it can only be _____ from one form to another.

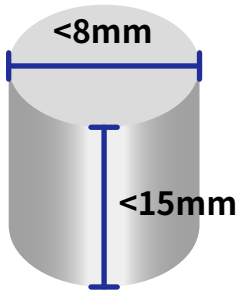
Activity II
Design and make LEG

Safety precautions for handling super magnets

Neodymium super magnets provide strong magnetic field. The following precautions must be taken.

1

Do not use super magnets with dimension greater than 8 (diameter) x 15 (height) mm.

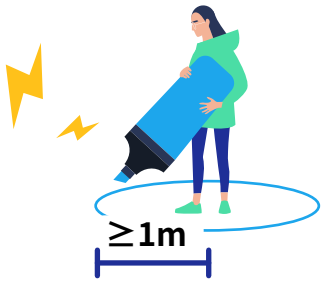


2

Wear heavy gloves with impact protection are strongly recommended.

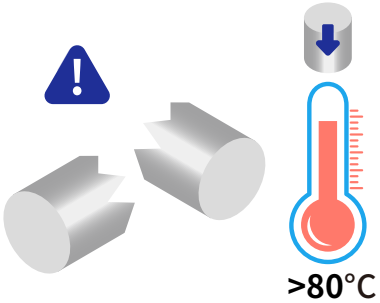
3

Move all ferromagnetic objects attracted by magnets at least 1m away from your field.



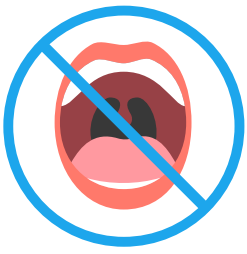
4

Do not bang super magents. Keep them below 80°C. They break easily and lose magnetism at high temperatures.



5

Never swallow super magnets. It can be life-threatening.

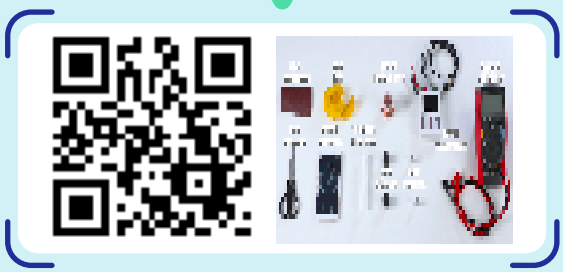


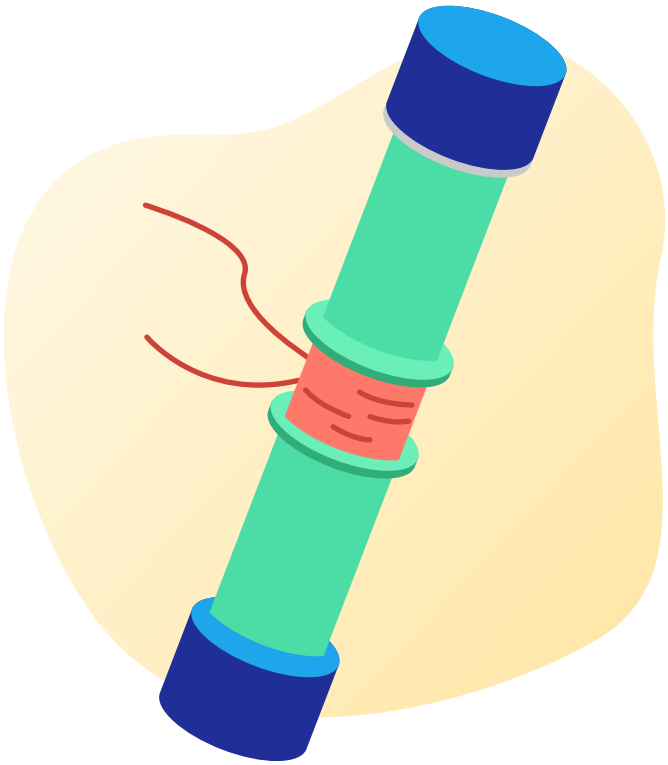
Introduction

In this activity, we will design and make a LEG, then investigate how the number of turns of the coil affects the generation of voltage.

Watch the video below and begin to construct your own LEG.

Video 2





Instructions

Shake the LEG and record the **maximum instantaneous peak-to-peak open-circuit voltage** ***(V)*** for different number of turns of the coil ***(N)***.

Results

Complete Table 1.

Number of turns of the coil *(N)*	Maximum instantaneous peak-to-peak open circuit voltage *(V)*
0	
50	
100	
150	

Table 1

Using the data in Table 1, plot a graph of *V* versus *N* by inputting the data in the Spreadsheet template

Download here: https://bit.ly/3PikJyT

and then insert the graph in the space below.

Graph 1

Questions

3 Using Graph 1, predict the value of *V* when *N* = 200.

4 With the use of the law of conservation of energy, what do you expect on the value of *V* if the LEG is shaken more frequently?

Conclusion

The more the number of turns of a coil in LEG, the more vibration energy can be converted to electrical energy.

Activity III
Real-world Application: Energy harvesting!

Introduction

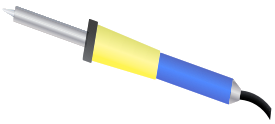
In this activity, we will study energy harvesting from walking using a LEG.

Watch the video to understand how energy is harvested from walking.

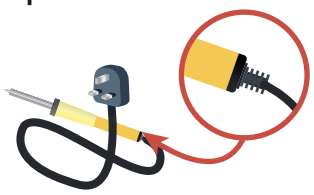
Video 3

Safety precautions for handling soldering iron and soldering gun

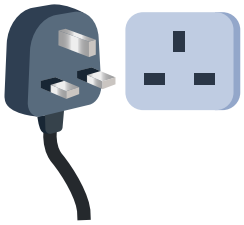
1. Soldering iron body should be made of steel, securely attached to a high strength plastic, or wood handle for good insulation.



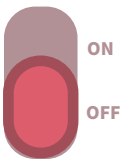
2. The supply cable should enter the handle through a rubber grommet, secured inside with a screw-down type clamp or equivalent.



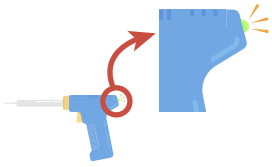
3. The soldering iron or soldering gun should be fitted with a 3-pin plug and properly fused.



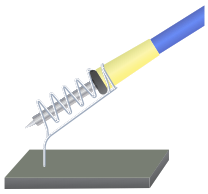
4. The ON/OFF switch of soldering gun should be biased to the 'OFF' position to minimise fatigue during long periods of use.



5. The pistol grip type soldering gun should preferably have an indicator light activated from the main ON/OFF switch.



6. The soldering gun or the soldering iron should be used with a proper stand.



7. Soft soldering should only be done where ventilation is sufficient to avoid the inhaling of harmful fumes.

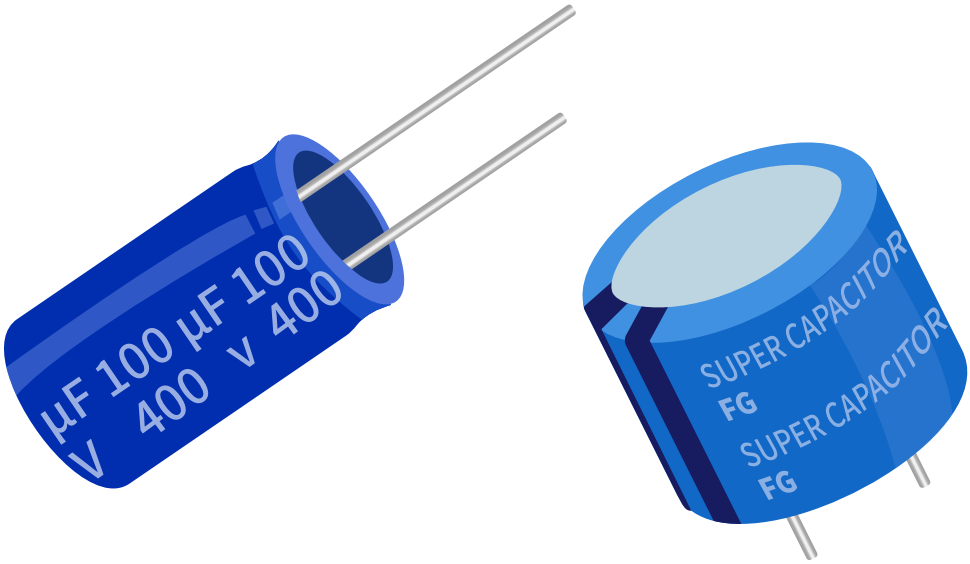
Background knowledge: Capacitor - An energy storage device

Capacitance is the capability of a capacitor to store electric charge and energy. The higher the value of the capacitance, the higher the energy storage capacity. The SI unit of capacitance is Farad (F).

The capacitance of the supercapacitor in this experiment is about 1 F.

Instructions

Construct the LEG as instructed. Measure the voltage of the supercapacitor for every 50 steps across walking.



Results

Capacitance of supercapacitor = _____

Complete Table 2.

Number of steps of walking	0	50	100	150	200	250	300	350	400
Voltage stored in the supercapacitor (V)									

Table 2

Questions

5 How much energy can you harvest from LEG after 400 steps?

(Hint: The energy E stored in a capacitor is given by $E = \frac{1}{2}(C \cdot V^2)$, where C is the capacitance and V is the voltage.)

6 Estimate the average number of steps you walk every day, and calculate the energy you can harvest in a year.

Average number of steps I walk every day: _____

Conclusion

Vibration energy can be harvested from our _____ (e.g. _____).

We can use LEG to convert wasted energy to _____ and then store the useful energy in a _____.