How many AA batteries?

Introduction

You need energy to make objects move and to keep devices such as mobile phones working.

You can calculate the energy stored in objects, such as an AA battery or a can of sugary drink. You can also calculate the amount of energy transferred, for example when sunlight is absorbed by a solar panel.

An important related idea is efficiency – how well a device transfers the input energy into useful output energy.

After completing this WebQuest, you should be able to:

- describe the changes in energy stores that happen when a system changes
- calculate the energy stores of various objects
- calculate the efficiency of various energy transfers.

Task

You are going to look at a variety of interesting systems that store energy:

- how many AA batteries would a car need to travel a certain distance?
- how many cans of sugary, fizzy drink would you need to climb Mount Everest?
- what area of solar panels would a UK household need to provide all its power?

You will then display your answers in a PowerPoint presentation.

Process

Step 1 – batteries

- Research the amount of energy stored in one AA battery.
- Research the amount of energy needed to drive a car 1 km.
- Use your findings to calculate how many AA batteries the car would need to travel 1 km.

Step 2 – drinks

- Research how much energy is stored in a typical 330 mL can of sugary, fizzy drink.
- Research the height of Mount Everest.
- Calculate the amount of gravitational potential energy you would gain if you moved from sea level to the top of Mount Everest.
- Use your findings to calculate how many cans of sugary drink you would need to climb the mountain.

Step 3 – solar panels

- Research how much energy from sunlight falls on an area of 1 m2 in one year in the UK.
- Research how much electricity a typical UK household uses in one year.

- If photovoltaic cells (solar panels) are 100% efficient, you would now be able to calculate the area of solar panels needed to power the household. But remember that devices waste energy and so cannot always be 100% efficient – so research the typical efficiency of solar panels.
- Use your findings to calculate the area of solar panels that a UK household would need to provide all its power.

Step 4 – the presentation

Present your results as a PowerPoint presentation.

Is there anything in them that your friends or family would find surprising? For example, would there be enough space in your neighbourhood or in the whole of the UK for the area of solar panels that would be needed?

Go further

If you have time, try coming up with your own questions. You could include some calculations about energy stored as kinetic energy and as elastic potential energy.

Sources

Battery energy storage in various battery sizes

Step 1 – batteries. Information about the energy stored in standard battery sizes. Try looking at the energy in joules (J) for an alkaline long-life battery.

https://www.allaboutbatteries.com/energy-tables.html

Transport energy and emissions: urban public transport

Step 1 – batteries. Look at Table 4 on page 6. It shows energy in MJ per vehicle kilometre for a medium-sized car.

http://oro.open.ac.uk/4378/1/PT_Energy_and_Emissions.pdf

Myth – Public transport doesn't really save energy

Step 1 – batteries. Find the table 'Life-cycle efficiency of transport modes'. This shows the energy use in MJ/pkm (megajoules per person-kilometre) for operating a car.

https://www.ptua.org.au/myths/energy/

Coca-Cola, Coke Classic calories – soft drinks – FDDB

Step 2 – drinks. The energy stored in 100 mL of Classic Coke shown as the calorific value in kilojoules (kJ).

https://fddb.info/db/en/food/coca-cola_coke_classic/index.html

BBC Bitesize – conservation of energy – gravitational potential energy

Step 2 – drinks. How to calculate gravitational potential energy.

https://www.bbc.co.uk/bitesize/guides/z4yj6sg/revision/2

Is my home suitable for solar panels? Greenleaf Innovations

Step 3 – solar panels. Map of the UK showing the total energy received from sunlight in one year in kilowatt-hours (kWh).

https://www.greenleafinnovations.co.uk/for-your-home/solar-panels-bristol-gloucestershire/is-my-home-suitable/

Home energy sources

Step 3 – solar panels. The average electricity consumption of a UK household in kilowatt-hours (kWh).

https://www.carbonindependent.org/15.html

How much electricity can I generate with solar panels?

Step 3 – solar panels. The typical efficiency of solar panels.

https://www.theecoexperts.co.uk/solar-panels/how-much-electricity

55 interesting facts about energy

Go further – Some fun facts about energy.

https://www.factretriever.com/energy-facts

BBC Bitesize – conservation of energy – kinetic energy

Go further – How to calculate kinetic energy.

https://www.bbc.co.uk/bitesize/guides/z4yj6sg/revision/1

Kerboodle – AQA GCSE Physics Student Book

Go further Topic P1.5 in the Student Book shows the equation to calculate elastic potential energy.

Conclusion

You have calculated the amounts of energy stored or transferred in different situations. Hopefully you will have seen at least one example that interested or surprised you. Keep looking around you – can you see any other examples of big energy stores or transfers?

House insulation

Introduction

It costs money to pay for oil, gas or electricity to heat your home. The colder it is the more heat is needed to keep a house warm. The cost of paying the heating bills during the cold months of the year can be very high.

Did you know that there are other ways of reducing heating bills without ending up with a cold house?

In this activity you will:

- research how homeowners can save money by insulating their houses better
- look at different ways that a house can be insulated and investigate the physics principles involved.

You will also compare different methods of insulation by looking at the initial financial investment required and the time it takes for the homeowner to save this amount of money, known as the payback time.

Task

Your task is to research the sources provided and to compare different techniques which can be used to improve the insulation of a house.

You will need to pay particular attention to the cost of installing better insulation and how much money will be saved in the long term.

You will then use your findings to produce a leaflet that could be given to homeowners. The leaflet should advise homeowners on how they can reduce their heating bills by insulating their home better.

Your leaflet must present the information clearly and be easy to read. It is a good idea to include tables and diagrams in your leaflet to show the results and conclusions from your research.

Process

Step 1: Research the different ways a house can be insulated better

Work through the sources and list the different ways that a homeowner can improve the way their house is insulated.

For each of the methods of insulation, write a short paragraph describing how the insulation reduces heat transfer. For example, does each method reduce heat loss by conduction, convection or radiation?

Step 2: Select two or more types of insulation to compare

Choose a minimum of two of the methods of insulation and use the sources to investigate the cost of installing each one.

You then need to research how much money a house owner will save on their electricity bill each year if they install this kind of insulation.

Finally, you have to calculate or research the payback time for each. The payback time is how long it will take before the homeowner has saved enough money to make up for the installation costs that they paid at the beginning.

You may find that different sources have slightly different data and different costs. You will have to make a judgement on what you think is a reasonable estimate based on the information that you have available.

Step 3: Evaluate the information and select what to include

You now need to sort out all of the information you have gathered and decide which information you will include in your leaflet. Some information can be organised into bullet points. You may also decide to include some illustrations or diagrams in your leaflet.

Remember who is going to read your leaflet and what information they will be interested in. Too much complicated information can have less impact than short and simple points and facts.

You may wish to include some extra tips from the extra sources available in this section on your leaflet.

Step 4: Put everything together and design your leaflet

You will have to decide how to present your information:

- How big will your leaflet be?
- How many columns will you use?
- What will the titles to each section be?
- How are you going to grab the attention of the reader and convince them that the information you have is important to them?

You may wish to share your completed leaflet with other members of the class, or some real homeowners such as teachers or family members.

Sources

Step 1: Research the different ways a house can be insulated better

This website gives a brief explanation of how insulators work and how best to save energy so it costs less to heat a house.

https://www.s-cool.co.uk/gcse/physics/energy-transfers/revise-it/how-can-we-stop-heat-moving

This website is about energy transfer. Explore the links on this page to find out more about heat, efficiency, etc.

http://www.gcsescience.com/pen-energy-power-heat.htm

Step 2: Select two or more types of insulation to compare

This webpage describes different types of insulation.

http://www.gcsescience.com/pen19-building-insulation-cost-calculation.htm

This is the website for the Energy Saving Trust in the UK.

https://energysavingtrust.org.uk/

This website provides information about different types of insulation. You will also find links to recommended suppliers' websites and to government grants.

http://web.archive.org/web/20070430194756/http://www.whatyoucando.co.uk/heat_keep_in

Step 3: Evaluate the information and select what to include

You may wish to include a few more tips from these extra sources in your leaflet.

This webpage gives practical advice on what to do to save money on heating costs.

https://www.thebalance.com/how-to-save-money-on-utility-bills-this-winter-1289897

This webpage lists fifty ways to save money on home heating bills.

http://www.chiff.com/society/green-homes.htm

Conclusion

Not only does insulating your home better cut your electricity bill, but it reduces carbon emissions into the atmosphere and helps reduce climate change and the pollution of our planet.

In this activity you have evaluated a number of different methods of improving house insulation. Hopefully the people who read your leaflet will learn something too!

Biofuels

Introduction

Although biofuels have been around for a long time, they are becoming more and more popular. Some cars in Brazil run on ethanol, a liquid made from sugar cane. In Europe biodiesel, commonly made from palm oil, is often available.

The costs of fossil fuels such as oil are growing higher and higher. Many people believe that biofuels should replace fossil fuels such as oil, coal and gas.

It is often claimed that biofuels are greener, causing less damage to the environment. Unfortunately, it's not so simple. The energy cost involved in growing biofuels can be higher than you might think.

Task

This WebQuest is separated into three sections. In the first section you will be asked to research and summarise what biofuels are, in particular to identify the difference between biofuels and fossil fuels.

In the second section the task is to investigate some different kinds of biofuels, how they are made, and what they are used for.

The third task is to present some pros and cons of biofuels. This section includes a case study on the effect of growing palm oil, partly for its use in biofuels, in Indonesia, the last remaining habitat of the orang-utan.

Finally, you will prepare a presentation of your findings in the form of a poster, a booklet or a PowerPoint presentation.

Process

Step 1: What are biofuels?

Use the sources to answer the questions:

- What exactly are biofuels?
- How are biofuels different from fossil fuels?

There is a lot of information in these sources. Some of it may also be useful for Steps 2 and 3. It is probably best if you record your notes and research in a Word document at this stage.

Step 2: Investigate some different kinds of biofuels

For the different kinds of biofuels, research how they are made and what they are used for. For example:

- bioethanol
- biodiesel
- biomethane
- others.

Step 3: Pros and cons

Research the sources and find out some of the advantages and disadvantages of biofuels.

Draw up a table or a chart to illustrate the pros and cons of biofuels. You may be able to categorise some of the pros and cons if they are specific to a particular kind of biofuel.

Case study: The orangutan

Investigate the specific case of palm oil plantations in Indonesia. Write a short report about the effect of the palm oil plantations on the orang-utan. Include some information about how palm oil can be used in biofuels.

Step 4: Prepare your presentation

Finally, you must prepare a presentation of your findings in the form of a poster, a booklet or a PowerPoint presentation.

Think carefully about which method you choose to present your findings. Choose the method that enables you to communicate the information most effectively.

Sources

Step 1: What are biofuels?

Explains what fossil fuels are.

https://www.nationalgeographic.com/environment/energy/reference/fossil-fuels/

Explains the difference between biofuels and fossil fuels.

https://auto.howstuffworks.com/fuel-efficiency/biofuels/biofuel-fossil-fuel2.htm

Step 2: Different biofuels

Explains what bioethanol is and outlines some of the benefits of using bioethanol.

http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_bioethanol.htm

Explains what biodiesel is and outlines some of the benefits of using biodiesel.

http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm

Webpage looking at how environmentally friendly this biofuel is.

https://www.biomethane.org.uk/

News piece about using plant materials to produce biodiesel.

http://large.stanford.edu/publications/coal/references/mortished2/

Step 3: Case study: The orangutan

Presents an article calling for help for the Sumatran orangutans. Click on 'Campaigns' on the left of the page.

https://www.orangutans-sos.org/take-action/learn/palm-oil/

Conclusion

The debate about biofuels goes on!

This task has encouraged you to investigate some facts about biofuels. You then used this information to evaluate some of the pros and cons connected with developing and using biofuels as a replacement for fossil fuels.

However, there are some decisions and choices to be made by society before everyone agrees that biofuels should be used universally.

Solar panels

Introduction

Solar panels heat water using clean, free, renewable energy. A solar heating system uses solar panels, a water storage tank and a system of interconnecting pipes and fluid to transfer energy from the panels to the tank.

Once the solar panels are installed, there is no cost involved in using the energy from the solar panels. However, some sources claim that it could take up to 100 years to reclaim the money spent installing a solar heating system.

In this WebQuest you will investigate this claim. Does it really take 100 years to save the money spent installing solar panels?

Task

This WebQuest will take you through a series of questions and calculations, based on information you will find in the sources and your knowledge of physics.

First you have to estimate the amount of hot water an average family uses and use this information to calculate the cost of heating the water.

You will then compare this value to the cost of installing solar panels to heat water and calculate a value for the payback time.

Finally, you are asked to make a judgement about any financial benefit of installing solar panels and to comment on some claims made about savings and payback time.

Process

Step 1: Installing solar panels

Familiarise yourself with how solar panels work and read some of the claims made about payback time for installing solar panels.

Step 2: Estimate the volume of hot water a typical family uses per month

Calculate how much energy in joules would be required to heat this volume of water to a temperature of 55 °C. Convert this energy into kilowatt-hours. You will need to decide what you will consider to be the initial temperature of the water.

Step 3: Calculate the cost of heating the water

Calculate how much it would cost to heat this amount of water using an electric water heater.

Step 4: Estimate the size of solar panels required and approximate installation costs

Use the information supplied in these sources to estimate the size of solar panels that would be required to heat the amount of water an average family uses per month. Estimate the approximate installation costs of installing the panels.

Step 5: Is it worthwhile installing solar panels?

Compare your answers and decide whether you think it is worthwhile installing solar panels to heat water. Are the claims in the websites about payback time justified? Does it really take 100 years to get your money back?

Sources

Step 1: Installing solar panels

Provides a basic explanation of how solar panels work.

https://energysavingtrust.org.uk/renewable-energy/heat/solar-water-heating

Provides details on the cost of solar panels.

https://www.greenmatch.co.uk/blog/2014/08/what-is-the-installation-cost-for-solar-panels

Explains what solar collectors are and how they work.

http://web.archive.org/web/20090307124547/http://www.greenworks-energy.co.uk/evacuated-tube-collectors.php#solar-etc-banner

Includes information about installation costs and savings on heating bills.

https://energysavingtrust.org.uk/renewable-energy

An article from 2008 which questions the cost effectiveness of installing solar panels.

https://www.independent.co.uk/environment/climate-change/solar-panels-take-100-years-to-pay-back-installation-costs-917202.html

Step 2: Estimate the volume of hot water a typical family uses per month

Calculates the water consumption of a household.

http://news.bbc.co.uk/1/hi/in_depth/629/629/5086298.stm

Explains the equation to calculate the energy required to heat water.

http://www.splung.com/content/sid/6/page/specificheat

Provides the mass of a litre of water.

https://thinkmetric.org.uk/principles/

Converts joules to kilowatt-hours.

https://www.calculateme.com/energy/joules/to-kilowatt-hours/

Step 3: Calculate the cost of heating the water

Provides examples of the cost of a kilowatt–hour (2008).

https://www.ukenergy.co.uk/why_switch_case_study

Presents a table of costs of a kilowatt-hour of electricity from British Gas.

https://www.britishgas.co.uk/content/dam/british-gas/documents/Online%20Energy.pdf

Step 4: Estimate the size of solar panels required and approximate installation costs

Includes information about installation costs and savings on heating bills.

https://energysavingtrust.org.uk/renewable-energy

Step 5: Is it worthwhile installing solar panels?

Includes information about installation costs and savings on heating bills.

https://energysavingtrust.org.uk/renewable-energy

An article from 2008 which questions the cost effectiveness of installing solar panels.

https://www.independent.co.uk/environment/climate-change/solar-panels-take-100-years-to-pay-back-installation-costs-917202.html

Conclusion

In this WebQuest you have made a number of estimates and calculations in order to make a value judgement about the effectiveness and cost effectiveness of using solar panels to heat water for domestic use. However, using solar energy has other benefits apart from cost. It does not pollute our environment, it is clean energy.

A short history of electricity

Introduction

The discovery of electricity, and subsequent technological developments, have had important effects on society.

After completing this WebQuest, you should be able to:

- describe electrical charge and how electric current flows
- describe how scientific theories develop over time.

Task

You are going to research key moments in the history of electricity, and then create a timeline. This could focus on key scientific discoveries and/or the various ways households use electricity.

Process

Step 1

Remind yourself of modern ideas about electricity.

Step 2

Read a short introduction into the history of electricity.

Step 3

Research the history of electricity. You could choose to focus on either scientific discoveries or technological inventions, or think about both.

Step 4

Summarise what you have learnt by drawing a timeline and annotating it.

Go further

If you have time, try looking in more detail at the effects that electricity has had on society. You could try thinking about magnetism as well.

Sources

Step 1 A reminder of our modern view of fundamental electrical concepts.

https://www.bbc.co.uk/bitesize/guides/z88hvcw/revision/1

Step 2 The early history of electricity from 600 BC to the 1900s. It looks at both scientific discoveries and technological inventions.

https://www.universetoday.com/82402/who-discovered-electricity/

Step 2 A brief introduction to the early history of electricity from ancient Greece to today. It compares scientific discoveries with modern ideas.

https://spark.iop.org/electric-charge-and-current-short-history#gref

Step 3 An interactive timeline of discoveries and inventions in electricity from ancient Greece to today. (Requires Adobe Flash Player.)

http://resources.schoolscience.co.uk/britishenergy/14-16/index.htm

Step 3 A list of inventions, including many electrical ones (but showing many non-electrical ones as well).

https://www.explainthatstuff.com/timeline.html

Step 3 An alphabetical list of scientists and inventors, 1706–1943. (The later section 'Emergence of a profession' is less useful.)

https://www.ecmag.com/section/your-business/brief-history-electricity

Step 3 Another summary of the history of electricity with scientific concepts first, from 2750 BC to 1960. This website lists lots of names and inventions. But you may need to look elsewhere to get a better understanding of each person and invention.

https://www.ideallighting.co.uk/2016/09/09/electricity-history/

Go further The effects on society from the invention of light bulbs.

https://americanhistory.si.edu/lighting/19thcent/consq19.htm

Go further This website includes both electricity and magnetism, and lots of details about the scientists. But it only looks at scientific discoveries (not inventions). It covers years 585 BC to 1802.

http://galileoandeinstein.physics.virginia.edu/more_stuff/E&M_Hist.html

Conclusion

You have researched the history of electricity – its scientific discoveries and its technological inventions.

Keep looking:

- What electrical technology do you see around you?
- Are there any parts of your life that would stay unchanged if electricity disappeared?
- What new inventions could you be using in the next few decades?

Plugs

Introduction

There are many different designs of mains electrical plug around the world. Some have two pins, whilst others have three pins. Different plug designs tend to have different levels of safety.

After completing this WebQuest, you should be able to:

- describe the three-core cable design of electrical appliances connected to the mains supply
- explain that the earth wire is a safety wire to stop an electrical appliance becoming live.

Task

You are going to research plug designs from around the world. You will then discuss which ones you think are the safest or have the best design.

Imagine that you are trying to persuade governments and manufacturers from around the world whether they should agree to use one plug design. You will create a presentation to persuade them.

Process

Step 1

Remind yourself of the wiring system used today in the UK.

Step 2

Review the different types of electrical plugs and sockets used today around the world.

Step 3

Research in more detail the advantages and disadvantages of the different designs.

Step 4

Use your findings to produce your presentation. It should persuade governments and manufacturers around the world whether you think it is a good idea to agree on one plug design.

Think about the best way to get your message across. Would it be more persuasive to have charts and graphs, or blocks of text?

Go further

If you have time, try thinking about plug designs used by industry, instead of by households. Would it be a good idea for industry to use more than one design?

Sources

Step 1 An introduction to the three-core mains connection (page 1) and the earth wire (page 2).

https://www.bbc.co.uk/bitesize/guides/z9b2pv4/revision/1

Step 2 A list of plug and socket designs used around the world today. There is also a link to a global map.

https://www.worldstandards.eu/electricity/plugs-and-sockets/

Step 2 Another list of plug and socket designs used around the world today. Use the tabs to view these as a map or list them by country.

https://www.iec.ch/worldplugs/map.htm

Step 3 An introduction to why there are so many different plug designs. It explains that there is one international standard.

https://www.mentalfloss.com/article/61040/why-are-electrical-plugs-different-europe

Step 3 An argument in favour of one plug design. (The 'caltrop' mentioned in the last sentence is a spiked weapon designed to hurt soldiers and horses when it is trodden on!)

https://www.fastcompany.com/3032807/why-england-has-the-best-wall-sockets-on-earth

Step 3 Explains why there are so many different plug designs, and the attempts being made to decide amongst them.

https://www.worldstandards.eu/why-no-universal-plug/

Step 3 Explains why earthing ('grounding') and the three-pin socket have become standard use in the USA.

http://amasci.com/amateur/whygnd.html

Go further Explains the different standards used in North America, including by industry.

https://download.schneider-electric.com/files?p_Doc_Ref=SPD_SADE-5TNRML_EN

Conclusion

You have reviewed the different types of electrical plug used around the world.

- Can you think of any other electrical appliances that have different designs in different countries?
- Does it matter that they are different?
- Are the differences good or bad?

Stability

Introduction

Some objects are carefully designed to be very stable, such as a Formula 1 car or a baby's highchair. This activity is about what factors affect this stability and at what point the object will topple over.

After completing this activity, you should:

- know how to improve the stability of an object
- know what makes an object topple.

Task

Your task is to work through the sources provided on stability, the centre of mass, equilibrium, and when objects topple. You will make notes about the relevant information as you read.

There are some key questions to help you. You will then be asked to select two or three examples of objects/situations where stability is important and apply what you have learnt to these examples. You will present your findings as a report or a Powerpoint presentation.

Process

Step 1: Work through the sources

Work through the sources provided on stability, the centre of mass, equilibrium, and when objects topple. Make notes about the relevant information as you read. Here are some key questions to help you.

- What is the centre of mass of an object?
- What is stability?
- What factors affect the stability of an object?
- How does the position of the centre of mass affect the stability of an object?
- Why do objects fall over? (Use your answers to the questions above to help answer this.)

Step 2: Apply what you have learnt

Choose two or three of the examples below and apply what you have learnt about stability to each object or situation. Explain how stability is important and what steps are taken to improve stability. You can either present your information as a report or a PowerPoint presentation. You can use images and diagrams in your presentation.

- a Formula 1 racing car
- a child's high chair
- a double-decker bus
- a crane
- a tractor
- a filing cabinet.

Step 3: Present your information

Present your information to your teacher, or to your class.

Sources

Structures – stability

An introduction to what makes a structure stable.

https://www.explainthatstuff.com/howbuildingswork.html

Stability of structures

An online chapter of a textbook that covers the issues of centre of mass and factors affecting stability.

https://www.scribd.com/document/177359821/Stability-of-Structure

Centre of Mass

A quick reminder of the principles of stability.

https://www.bbc.co.uk/bitesize/guides/zgncjty/revision/2

Cranes and lifting machines

A source looking at ancient lifting devices.

https://www.lowtechmagazine.com/2010/03/history-of-human-powered-cranes.html

Stability, Balancing and Equilibrium

A webpage on general stability featuring some helpful diagrams.

https://www.cyberphysics.co.uk/topics/forces/stability.htm

Conclusion

In this WebQuest you have learnt that a wide base and a low centre of mass improve the stability of an object. You have also learnt that if the line of action of the weight of an object lies outside the base of the body, there will be a resultant moment and the body will tend to topple.

Surviving falls

Introduction

There is evidence to suggest that not only can cats survive falls from tall buildings but they are actually more likely to escape serious injury if they fall from a height of eight storeys rather than four storeys. You will investigate the physics behind this remarkable phenomenon and explain it by considering air resistance, weight, and terminal velocity.

Note that while cats *can* survive falls from many storeys up, their survival is by no means guaranteed – and even if they do live, they may sustain life-threatening injuries. Please do not experiment on your cat.

After completing this activity, you should be able to:

- describe what happens to the forces on an object as it falls
- explain what happens to the motion of a falling object in terms of the forces acting on it
- explain why different objects may reach different terminal velocities.

Task

In this WebQuest you will strengthen your understanding of falling and terminal velocity while discovering why cats sometimes survive falls from many storeys high, which would kill a human.

First you will find out about some of these 'miracle cats'.

Then you will revise terminal velocity using websites containing notes, illustrations, and simulations to remind yourself about why falling objects eventually stop accelerating. You will use your understanding, together with some websites about falling cats, to work out and write about how cats survive these incredible falls.

Finally, you will learn about a daredevil sporting activity which uses a new technology for reducing the terminal velocity of a falling human.

Process

Step 1: Falling cats: the evidence

Look at the evidence that shows cats can, sometimes at least, survive falls from tall buildings. The first two websites are short news articles about 'miracle cats'. The third is an article about falling cats, which includes a graph showing survival rates based on many falls by cats. Though the data is genuine, the graph has been designed to look amusing rather than serious. Before continuing, make a list of any criticisms you think your science teacher would make if you handed in this graph after an experiment.

What do we learn about falling cats and humans from this graph? Describe in a few sentences what it shows.

Step 2: Terminal velocity

The results you have just seen can be explained, at least partly, using the idea of terminal velocity. Use the websites to remind yourself why falling objects reach a terminal velocity.

Step 3: How do cats do it?

There are two main reasons why cats are so good at surviving falls: one is that they can twist around to land feet-first; and the other reason is related to their terminal velocity. You are going to focus on terminal velocity.

In your own words, write a step-by-step description, with labelled force diagrams, of what happens to the forces and the motion of a cat as it falls. Then explain why cats are more likely than humans to survive a fall from a high building. Your description and explanation should involve air resistance, resultant forces, and terminal velocity. Aim for a length of 1–2 pages altogether. You can use the websites from this step and from Steps 1 and 2 to help you.

Step 4: How can humans do that?

Without special equipment, humans are almost always killed or injured by falls of more than a few metres onto a hard surface. You already know about parachutes, but in the last few years there has been a new invention – the 'wingsuit'.

What is the typical terminal velocity of a person with and without a wingsuit? Why is it difficult to land safely in a wingsuit without using a parachute as well? Use the websites given, or do your own web search, to find out.

Sources

Step 1: Falling cats – the evidence

A short news article about a cat that survived a fall from a 17th floor balcony.

https://time.com/3321526/canada-cat-escapes-17-storey-fall/

A short news article about a cat that survived a fall from a 19th floor window.

https://www.cbsnews.com/news/sugar-the-miracle-cat-survives-19-story-fall/

An article about falling cats, based on real data. Look at the graph titled 'Fatal falls' (on page 5).

http://www.jareddiamond.org/Jared_Diamond/Further_Reading_files/Diamond%201989.pdf

Step 2: Terminal velocity

Notes and diagrams explaining how falling objects reach terminal velocity.

https://www.bbc.co.uk/bitesize/guides/zff82hv/revision/1

A simulation of a falling object. You can choose either a jar of jam or a heavy mass, with or without a parachute, by clicking on the objects at the top right. Watch what happens to the forces, speed, and acceleration as the object falls.

https://www.physicsclassroom.com/Physics-Interactives/Newtons-Laws/Skydiving/Skydiving-Interactive

Step 3: How do cats do it?

An article about how cats survive falls.

https://www.nytimes.com/1989/08/22/science/on-landing-like-a-cat-it-is-a-fact.html

Another article about how cats survive falls.

https://www.bbc.co.uk/news/magazine-17492802

This article lacks some of the physics detail, but makes some important points about being careful with data collection and bias.

http://www.todayifoundout.com/index.php/2010/11/domestic-cats-can-fall-from-any-height-with-a-remarkable-survival-rate/

Step 4: How can humans do that?

A summary of the basics of wingsuit flying. If you want to know more beyond GCSE level, continue on to page 2 and beyond.

https://adventure.howstuffworks.com/wingsuit-flying.htm

There is some difficult language and concepts in this website, but it also includes interesting points and a video clip of wingsuit flyers.

http://blogs.bu.edu/biolocomotion/2011/09/25/the-physics-of-wingsuits/

Conclusion

In this WebQuest you have reinforced your understanding of falling and terminal velocity. Through writing about falling cats, you have practised describing and explaining what happens to an object as it falls. You have also researched and explained why different objects may reach different terminal velocities, and how humans can lower their terminal velocity.

If you haven't already, read the falling cats article from Step 1 to find out much more about how the falling cat data was collected and what it can tell us.

If you have found this topic interesting and would like to find out more, you could go further by searching the web or by exploring any of the following websites:

http://www.viewpure.com/XqL9siGDeBA?ref=search

https://www.theglobeandmail.com/technology/ants-slow-fall-key-to-survival/article4275684/

Safe driving

Introduction

The stopping distance of a vehicle depends on the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels while braking (braking distance). The UK's highway code says that the 'typical stopping distance' at 60 mph (96 km/h) is 73 m, made up of a thinking distance of 18 m and a braking distance of 55 m.

There is a reason for using the word 'typical': stopping distances can vary dramatically depending on how the person is driving and the conditions they are driving in. There are a large number of factors which can make the difference between life and death when a car needs to stop quickly.

Task

In this WebQuest you will research the factors that affect the stopping distance of a car and categorise them into whether they affect thinking distance, braking distance, or both.

You will then research one particular factor that affects the stopping distance, choosing from: driving speed, weather conditions, tyre conditions, using a mobile phone, drink driving, and tiredness. You will prepare a leaflet about your chosen factor, designed to communicate a message effectively to a particular target audience.

Process

Step 1
Read through the general sources and make sure that you understand the differences between thinking distance, braking distance, and stopping distance.

Step 2

Briefly read all the other sources. List the different factors that affect stopping distance that are mentioned. Specify whether each of the factors affects the thinking distance or the braking distance.

Step 3

Select a particular factor that you will focus your research on, such as weather conditions, or using a mobile phone when driving. Identify a target group that might need or want to know more about this. For example, people who drive long distances for their jobs may be particularly susceptible to tiredness; inexperienced drivers may be less likely to know about the importance of tyre conditions; and according to UK government statistics, young men are the people most likely to drink and drive. Thoroughly read the sources that are relevant to your chosen factor and gather all the information you need for designing your leaflet.

Step 4

Design and prepare a leaflet about the factor you have been researching. Write it with your chosen target group in mind – your leaflet should aim to grab their attention and then persuade or inform them about the issue. Include some physics and statistics, along with helpful diagrams and simple explanations. Remember to write about stopping distance, and your chosen factor's effect on it, as a key part of your leaflet.

Step 5

Share your leaflet with other members of your class. You could also share your leaflet with a wider audience, for example by arranging to have it shown on the school website or for copies to be left in a sixth form common room.

Sources

Step 1: Thinking distance, braking distance, and stopping distance

Chart of stopping distances from The Highway Code.

https://www.highwaycodeuk.co.uk/answers/what-is-the-stopping-and-braking-distance-of-a-car

Brief explanation of stopping distance, thinking distance, and braking distance from BBC Bitesize GCSE.

https://www.bbc.co.uk/bitesize/guides/zff82hv/revision/3

Steps 2–4: Factors that affect stopping distance

An article by road safety charity Brake about the effect of speed on stopping distances.

http://www.brake.org.uk/rsw/15-facts-a-resources/facts/1255-speed

An Australian government website that explains how stopping distance is affected by driving speed.

https://www.qld.gov.au/transport/safety/road-safety/driving-safely/stopping-distances

Road safety advice for drivers, by the Royal Society for the Prevention of Accidents (RoSPA).

https://www.rospa.com/Road-Safety/Advice/Drivers

Information on the UK government's THINK! campaign on speeding on urban and rural roads.

https://www.think.gov.uk/themes/speed/

Advice from the driving association AA about driving in wet conditions.

https://www.theaa.com/driving-advice/seasonal/driving-through-flood-water

Information from Safer Motoring about driving in different weather conditions, including heavy rain, snow, and ice.

http://www.safermotoring.co.uk/DrivingWeatherConditions.html

Information from the Royal Society for the Prevention of Accidents (RoSPA) about the results of tests on how tyre tread depth affects stopping distance.

https://www.rospa.com/rospaweb/docs/advice-services/road-safety/vehicles/tyre-tread-depth.pdf

Information from tyre seller etyres about how the condition of car tyres affects stopping distances.

https://www.etyres.co.uk/uk-tyre-law

Information from tyre safety organisation TyreSafe about tyre tread depth and safety.

https://www.tyresafe.org/tyre-safety/tread-depth/

Information from the Royal Society for the Prevention of Accidents (RoSPA) about the dangers of using a mobile phone while driving.

https://www.stoppingdistances.org.uk/facts/phones/

Website by the UK government's THINK! campaign about the dangers of using mobile phones while driving. Includes links to adverts and posters from a campaign to raise awareness of the issue.

https://www.think.gov.uk/campaign/mobile-phones/

Information from the Royal Society for the Prevention of Accidents (RoSPA) about the dangers of driving after drinking alcohol.

https://www.stoppingdistances.org.uk/facts/drink/

Website by the UK government's THINK! campaign about the dangers of driving after drinking alcohol. Includes links to adverts and posters from their campaigns to raise awareness of the issue.

https://www.think.gov.uk/campaign/50-years-of-drink-drive-campaigns/

Summary of aims and strategy of the UK government's THINK! campaign on driving and drinking.

https://www.gov.uk/government/news/think-campaign-urges-young-men-to-stop-their-friends-drink-driving

Website by Road Safety Scotland about the risks of driving while tired.

https://roadsafety.scot/topics/driver-fatigue/

Conclusion

In carrying out this WebQuest you have learnt more about the factors that affect the stopping distance of a car. You have researched relevant information and presented it in an appropriate way for your target audience. In doing so, you have thought about how to influence others by using scientific data and information in order to reduce the chances of accidents on the roads.

Supersonic skydive

Introduction

Up in the atmosphere, pressure changes with altitude. As the pressure changes, the speed of sound also changes.

As an object falls through the atmosphere, it accelerates until it reaches its terminal velocity.

After completing this WebQuest, you should be able to:

- state that it is not only moving objects that have varying speed and that the speed of sound can also vary
- calculate the average acceleration of an object using the equation:
  $$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$
- explain why a falling object will eventually move at its terminal velocity.

Task

On 14 October 2012, Felix Baumgartner jumped from a balloon 39 km up, and fell freely until he was travelling faster than the speed of sound.

You are going to:

- research some facts about his jump
- do some calculations
- then present your findings as a report.

Process

Step 1

- Research Felix Baumgartner's jump – look for infographics, videos and articles.

Step 2

- Revise the ideas of speed and acceleration.
- Look up the amount of time Felix Baumgartner was in free fall, and over what distance.
- Calculate his average speed.
- Look up his maximum speed.
- Calculate the time it would have taken for him to accelerate to his maximum speed from rest. Assume that the only force acting on him was gravity.
- Compare your value with the measured value. Try to explain why they are different.

Step 3

- Explain why Felix Baumgartner reached terminal velocity.
- Explain why his terminal velocity is different from the terminal velocity of someone falling freely near sea level.

Step 4

Produce a report summarising what you have learnt about the jump.

Go further

If you have time, try thinking about the idea of buoyancy to explain why Felix Baumgartner's balloon rose. The balloon expanded as it went higher – try explaining why that happened. Or try explaining another aspect of the jump, such as the physics of how he was kept safe.

Sources

Step 1 An infographic introducing Felix Baumgartner's jump.

https://visual.ly/community/Infographics/science/dive-stratosphere-felix-baumgartner

Step 1 A video of Felix Baumgartner's jump. (You can see the jump itself from 3 minutes 25 seconds.) The web page states the maximum speed and free fall time, and discusses terminal velocity. It gets very technical at the end, so you may want to skip the last five paragraphs.

http://exploriments.blogspot.com/2012/11/fearless-felixs-free-fall.html

Step 1 A newspaper article about Felix Baumgartner's jump, including data.

https://www.telegraph.co.uk/news/science/space/9849206/Felix-Baumgartner-fell-faster-than-we-thought-supersonic-skydiver-hit-Mach-1.25.html

Step 2 A reminder of the ideas of speed (page 1) and acceleration (page 3).

https://www.bbc.co.uk/bitesize/guides/z3bqtfr/revision/1

Step 3 The physics of Felix Baumgartner's jump, including terminal velocity.

https://www.livescience.com/23710-physics-supersonic-skydive.html

Go further More data about Felix Baumgartner's jump. It also discusses buoyancy.

https://www.wired.com/2012/02/stratos-space-jump-can-you-fall-faster-than-the-speed-of-sound/

Go further More information about Felix Baumgartner's jump. (Note: A lot of the information is in imperial units instead of SI units.)

https://www.redbull.com/int-en/projects/red-bull-stratos/achievements

Conclusion

You have used your knowledge of physics to understand what happened during the first-ever supersonic skydive.

Keep looking around for other examples of:

- forces that cause changes to motion
- terminal velocity.

Electrosmog – bad for our health?

Introduction

Electromagnetic waves have many practical applications, such as microwaves used in microwave ovens and radio waves used in Wi-Fi. Scientists often evaluate risks and make recommendations. These are then used by governments to make laws to protect citizens from harm caused by human technology.

After completing this WebQuest, you should be able to:

- describe and explain some practical applications of electromagnetic waves
- evaluate evidence and arguments for and against using some common technological applications
- evaluate risks in science and in society, including people's perception of risk.

Task

You are going to research the claims that electromagnetic waves (especially radio waves and microwaves) from technologies are making people ill. You will then create a 2-minute TV or radio piece for people who are worried about these claims.

Process

Step 1

Revise the parts of the electromagnetic spectrum. Look at what they are used for. Look at what the accepted scientific theories say about the harm that can be caused by different parts of the spectrum.

Step 2

Read the advice that is usually given to people about the evidence that radio waves can cause harm.

Step 3

Research the evidence about people who claim to suffer from electromagnetic hypersensitivity syndrome.

Step 4

Present what you have learnt as a 2-minute TV or radio piece. Create it for people who are worried about using electrical appliances in their homes, such as microwave ovens and Wi-Fi.

Based on the evidence you have read, are there are any precautions you would advise these people to take?

Go further

If you have time, try looking at a broader range of information sources. Be very cautious – are the sources trustworthy and objective?

Sources

Step 1 An introduction to the parts of the electromagnetic spectrum (page 1), their uses (page 3), and their hazards (page 4).

https://www.bbc.co.uk/bitesize/guides/z66g87h/revision/1

Step 2 A summary of the risks of developing cancer from radio waves ('radiofrequency waves' or 'RF waves').

https://www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html

Step 2 A report from a well-respected organisation. It summarises all of the available evidence of harm caused by radio waves ('radiofrequency waves' or 'RF waves'). Go to page 4 to see a useful two-paragraph conclusion.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/333080/RCE-20_Health_Effects_RF_Electromagnetic_fields.pdf

Step 2 An interesting article about the possible risk from using microwave ovens.

https://greatist.com/health/are-microwaves-really-health-hazard#1

Step 3 An article with very balanced arguments. It discusses the evidence around electromagnetic hypersensitivity syndrome (EHS).

https://www.washingtonpost.com/news/the-intersect/wp/2015/08/31/are-wifi-allergies-a-real-thing-a-quick-guide-to-electromagnetic-hypersensitivity/

Step 3 Very technical, so do not worry if you find it difficult to read. Scientists communicate with each other through peer-reviewed articles like this one, and this type of article is highly respected. Scroll down and read the last-but-one sentence (beginning 'Despite the conviction...'), which is quite clear.

https://www.ncbi.nlm.nih.gov/pubmed/19681059

Go further A leaflet written by a group that helps people who claim to have been affected by electromagnetic waves. Note the evidence that is quoted in the leaflet to support the group's point of view.

http://www.es-uk.info/wp-content/uploads/2018/11/02.1-ES-UK-Information-Leaflet-2018.pdf

Go further A blog post claiming that Wi-Fi will not make you ill. Note the emotive language used in the post – do you think the writing is objective? Note the evidence that is quoted in the post to support the writer's point of view.

https://bigthink.com/neurobonkers/wifi-wont-make-you-ill-but-thinking-it-will-really-can

Conclusion

You have read a range of evidence and views about whether radio waves are likely to cause people harm.

Look out for other situations where scientists are expected to give evidence-based, objective advice to reduce the risk of harm.

X-rays or ultrasound?

Introduction

X-rays and ultrasound waves are often used in medical imaging scans. X-rays and ultrasound waves each have different uses and hazards.

After completing this activity, you should be able to:

- describe the hazardous effects that X-rays can have on human body tissue, and explain that X-rays are ionising radiation that can cause the mutation of genes and cancer
- describe some technological applications of X-rays and ultrasound that are used every day, and evaluate the evidence and arguments for and against their use.

Task

You will research how X-ray and ultrasound scans work in medicine. You will consider their different uses and their hazards and risks.

You will then create a short pamphlet for hospital patients who need an X-ray or an ultrasound scan.

Process

Step 1

Research the idea of X-rays:

- how X-ray imaging works
- what medical X-ray images are used to detect
- the harm they might cause.

Step 2

Research the idea of ultrasound waves:

- how ultrasound imaging works
- what medical ultrasound images are used to detect
- the harm they might cause.

Step 3

Write a pamphlet to explain X-ray and ultrasound scans to hospital patients. Make sure the differences between these different types of scans are clear.

Go further

If you have time, look at another medical imaging technique, such as computed axial tomography (CAT/CT) or magnetic resonance imaging (MRI).

Sources

Step 1 A clear, simple introduction to X-ray medical scans.

https://wonderopolis.org/wonder/how-does-an-x-ray-work

Step 1 A more advanced website. It has a clear discussion of the harm X-rays might cause.

https://www.nibib.nih.gov/science-education/science-topics/x-rays

Step 2 A simple introduction to ultrasound medical imaging.

https://www.bbc.co.uk/bitesize/guides/z2dtv9q/revision/2

Step 2 Another introduction to ultrasound imaging.

https://wonderopolis.org/wonder/can-you-see-sound

Step 2 This uses more advanced language. But it clearly explains how ultrasound scans work. Scroll down the page to read a useful, short section ('Are there risks?') about the possible harm from ultrasound waves.

https://www.nibib.nih.gov/science-education/science-topics/ultrasound

Step 2 A brief discussion of the uses and dangers of EM waves.

https://www.bbc.co.uk/bitesize/guides/z32f4qt/revision/3

Step 3 A comparison of ultrasound waves and X-rays. You may find the language quite difficult.

https://www.ultrasoundschoolsinfo.com/whats-the-difference-between-ultrasounds-and-x-rays/

Go further An introduction to magnetic resonance imaging (MRI).

https://www.livescience.com/39074-what-is-an-mri.html

Go further An introduction to computed axial tomography (CAT/CT) imaging.

https://www.nibib.nih.gov/science-education/science-topics/computed-tomography-ct

Conclusion

You have used your knowledge of physics to help hospital patients better understand the scans they are going to have.

If you found this topic interesting, you can find out about the working lives of diagnostic radiographers at https://www.healthcareers.nhs.uk/explore-roles/allied-health-professionals/radiographer-diagnostic

Magnetic therapies

Introduction

A large number of companies in the UK and overseas sell 'magnetic therapy' products, such as magnetic bracelets; magnetic straps and braces for wrist, knee, or elbow joints; magnetic insoles for shoes; and even magnetic mattresses. Some of the companies claim that these items can relieve pain, cure illnesses, improve your general health, and improve your sporting performance.

It is estimated that people around the world buy hundreds of millions of pounds worth of magnetic therapy products each year. Meanwhile, scientific research has been carried out, and is still going on, to investigate whether these products have any positive effects on the human body.

Task

Imagine that a friend of yours is a very keen sports player who is trying to improve their performance. They sometimes have pain and stiffness in their knee because of a past injury. They are thinking about buying some magnetic therapy products, such as a magnetic knee brace to reduce the pain in their knee, and magnetic bracelets or headbands to make them more successful in training and sports competitions.

You are going to:

- research magnetic therapy products
- look for evidence of whether or not they are effective
- write a letter to your friend, advising them whether or not to buy a magnetic therapy product, and why.

Process

Step 1: Understand the key terms

When you read about magnetic therapy in later steps you will come across the phrases 'placebo effect', 'clinical trial', 'controlled trial' (a trial which uses a 'control group'), and 'double-blind trial'. To fully understand the sources in steps 2 and 3, you will need a basic understanding of what these terms mean. Use the sources to find out about the placebo effect and different types of clinical trial.

Step 2: Research what magnetic therapy companies say about magnetic therapy

You are going to visit the websites of some companies that sell magnetic therapy products. Several sources are given, but companies can come and go quite quickly. If you find that some of the links are out of date you may need to do your own web search to find more.

Search the company websites for scientific claims and explanations. Use your scientific knowledge and understanding about magnetism to evaluate the claims made. Make rough notes of anything you would like to mention in your letter.

Note: some of the web pages contain a lot of information. Focus mainly on the sections that relate to properties of magnets and magnetism that you have learnt about, and skip any sections that are beyond your understanding at the moment. Bear in mind, though, that some of the claims and explanations may not actually make sense. If you find the amount of information overwhelming, choose just one or two websites to focus on.

Step 3: Research what other sources say about magnetic therapy

Use these sources to find out what some other people and organisations, including scientists and doctors, say about magnetic therapy products. Again, focus mainly on scientific claims and explanations. Make notes of things you plan to mention in your letter.

Step 4: Write a letter

Write a letter to your friend, advising them on whether or not you recommend magnetic therapy products, and why. Include facts and scientific arguments. Your letter should be one to three pages long, and organised into paragraphs.

Sources

Step 1: Understand the key terms

Article about the placebo effect and alternative medicines (such as magnetic therapy, acupuncture, or homeopathy). Read the first two sections of the article.

https://www.nhs.uk/conditions/complementary-and-alternative-medicine/

Five-minute video about the placebo effect.

https://webarchive.nationalarchives.gov.uk/+/http://www.nhs.uk/video/pages/placeboeffect.aspx

Notes about clinical trials, including blind trials and double-blind trials.

https://www.bbc.co.uk/bitesize/guides/zpn9q6f/revision/3

Step 2: Research what magnetic therapy companies say about magnetic therapy

Information about how magnetic jewellery products work.

https://www.overstock.com/guides/magnetic-bracelets-benefits-explained

Article about how BIOMAG magnetic products work.

https://www.biomagtherapy.com/index.php?route=information/information&information_id=7

Article about how Trion:Z magnetic products work.

https://www.trionz.com/about-trionz/magnetic-therapy-wellbeing/

Step 3: Research what other sources say about magnetic therapy

Question and answer about whether blood responds to magnets.

https://www.thenakedscientists.com/articles/questions/blood-magnetic

Short article about a piece of research into whether magnetic bracelets relieve the pain of arthritis.

https://www.newscientist.com/article/dn6813-magnetic-bracelet-pain-relief-probably-placebo-effect/

Article by a neurologist (a doctor who specialises in the nervous system) about whether magnetic therapy can work as a pain reliever.

https://www.huffpost.com/entry/magnetic-therapy-are-magnets-for-pain_b_801664?guccounter=1

Article exploring whether magnetic therapy works.

https://www.livescience.com/40174-magnetic-therapy.html

Short article from the British Medical Journal, by a professor of medicine and a professor of physics, about whether magnetic therapy products work.

http://dcscience.net/finegold-flamm-bmj-06.pdf

Conclusion

In this WebQuest you have used your own knowledge and understanding of magnetism to examine the claims made by some companies that sell magnetic therapy products, and other claims, often based on scientific research, that these products do not work.

As well as giving you an opportunity to use what you have learnt about magnetism, this WebQuest also gave you practice in questioning and critiquing information and arguments (for example, by being aware of what the source is, and whether it is likely to be biased, and by evaluating the evidence for claims that are made). This is part of a range of skills called 'critical thinking'. Critical thinking is important for scientists, who need to evaluate methods and evidence to decide whether the conclusions are justified.

If you have found this WebQuest interesting and would like to find out more, you could go further by searching the web or by exploring any of the following websites:

https://www.bbc.co.uk/programmes/p01s6fcx

https://sciencebasedmedicine.org/can-magnets-heal/