(Don’t) look up!	
	Measuring impacts from space

Metadata

General Info

Title: (Don't) Look up!

Short description: In this exercise students use the Down2Earth Impact Calculator to investigate what happens when an asteroid or comet hits the Earth. Through the investigation, students become acquainted with kinetic energy and frequency of impacts from space while also practising making graphs.

Keywords

impact, calculator, comet, asteroid, planet, potential energy, kinetic energy, altitude

Educational Context

Context: In this activity, students investigate the effects of impacts of asteroids/comets on life on Earth, and look at what affects the results of these impacts. At the end they discuss how scientists and technology can be used in the event that a comet is discovered to be on a collision course with the Earth (as is the premise of the recent Netflix film, Don't Look up). They present their ideas on methods that can be used to save the planet in this scenario and reflect on the methods and tools they used.

Age: 11 - 14

Prerequisites: basic information about the Solar System, graph plotting

Lv. Of difficulty: 2

Aggregation Level:

Duration : 1-2hrs but can be extended

Educational Objective

Cognitive Objectives

- To learn about impacts from space
- To learn how to draw conclusions from simulated data via graphs/tables

Affective

- To understand the importance of cooperation in Astronomy and science in general.
- To understand what the effects of an asteroid or comet impact with Earth would be.
- To understand the difficulties in mitigating an impact with the Earth
- To understand the importance of technology's evolution in science.

Psychomotor

- To be able to use mathematical formulae/equations, and plot graphs.

Subject Domain

Big Ideas of Science

Students will be investigating how the different parameters of impactors affect life on Earth.

Impacts on Earth and a form of natural hazards. Scientists work on tracking these objects.

Subject Domain

Astronomy, Environmental Science, Physics

Orienting & Asking Questions

If you look up at our night sky, what can we see?

Stars, planets and the Moon.

What does the Moon look like? Can you describe it? Take a look at this image if you need help:

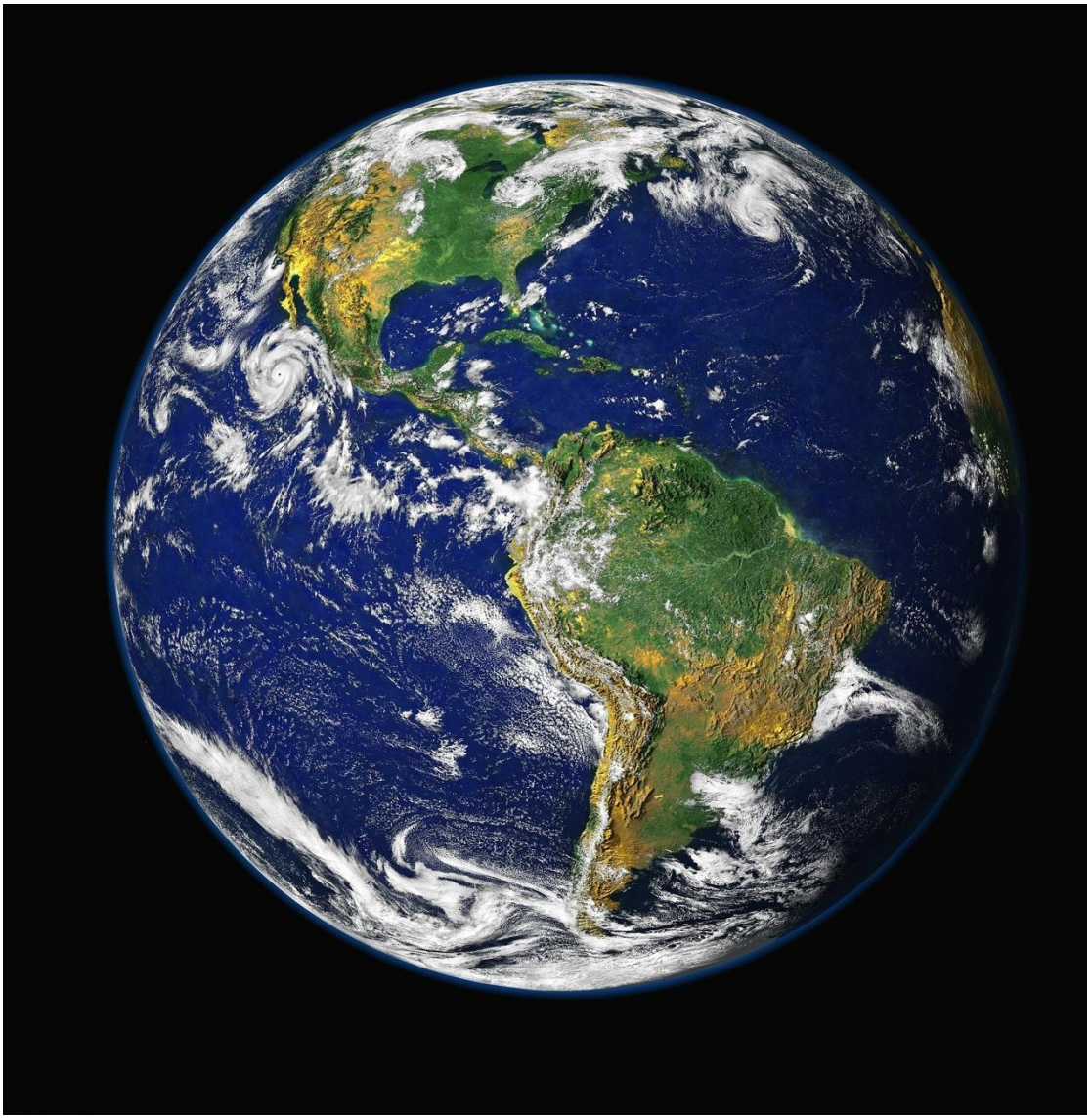
(Image Credit: NASA/Goddard Space Flight Center/Arizona State University)

What features can you see on the Moon?

There are mountains, valleys, ridges…what are these dark patches? And what about these circular features? Do you know what they are? The circular features are craters, and the dark patches are called the Mare, or 'Seas' on the Moon. The seas on the Moon don't contain water like our seas on Earth do - they are basically larger impact craters where something has smashed into the Moon in the past and liquid rock flowed into the crater, creating what we see today.

So, there's evidence on the Moon that it has been hot (or impacted) by objects in the Solar System in the past. But can we see the same thing on the Earth?

Take a look at this picture of the Earth – what do you see? How does it differ from the picture of the Moon?



We can see that over 70% of the Earth is covered in water. The white patches swirling across the planet are clouds – so we have weather on the Earth (unlike on the Moon where there is no weather). We have land and deserts and also ice caps too. And if you look closely, you can also see a thin blue fuzzy ring around the Earth – do you know what that is? It's the atmosphere. This acts as a protective blanket around our planet so that if anything falls from space onto the Earth, it burns up (but maybe not totally) in the atmosphere.

How else does the picture of the Earth differ to the picture of the Moon? The craters are not really visible in this image. So does that mean that we don't have craters on the Earth, or that we haven't been hit by anything from space in the past?

Have a look at the picture below:

What links dinosaurs with the topic in this activity?

65 million years ago, a large rock from space smashed into the Earth off the Gulf of Mexico in the Yucatan peninsula, and caused the extinction of the dinosaurs. So we know our planet has been hit in the past – do we have any other evidence of this?

Take a look at the pictures below:

Do you know what these are? Impact craters on the Earth! The reason that we don't see as many impact craters on the Earth as we do when we look on the Moon is because our planet's surface is constantly changing due to weathering/erosion, so very old impact craters may have been 'washed away' by the weather in the local area. We also have a lot of water on the Earth, so some objects may land in there rather than on the land, so we wouldn't see a crater. And remember, we also have our atmosphere which serves to protect us from incoming objects.

In 2013, over Chelyabinsk in Russia, a fireball was seen in the sky, early in the morning. Lots of video footage was obtained of this piece of rock from space entering the Earth's atmosphere, and from that, scientists were able to estimate where any meteorite fragments would be found. In this instance, the size of the object coming through the Earth, combined with its angle of entry, mass and velocity, meant that it didn't create a crater on the Earth, but broke up in the atmosphere. Watch the video in the link below to see it breaking up:

https://en.wikipedia.org/wiki/File:%D0%92%D0%B7%D1%80%D1%8B%D0%B2_%D0%BC%D0%B5%D1%82%D0%B5%D0%BE%D1%80%D0%B8%D1%82%D0%B0_%D0%BD%D0%B0%D0%B4_%D0%A7%D0%B5%D0%BB%D1%8F%D0%B1%D0%B8%D0%BD%D1%81%D0%BA%D0%BE%D0%BC_15_02_2013_avi-iCawTYPtehk.ogv

More recently, fireballs have been observed over the UK, leading to meteorites (small chunks of rock/iron) from these solar system objects, being discovered on the ground. One example was the Winchcombe meteorite fall in 2021 – see the video below:

https://www.youtube.com/watch?v=zn55Hsuefu4

and also in May 2022, a fireball was seen across the skies of the UK, and scientists were able to estimate that meteorites from this dazzling site could be found in South Wales – see the video below:

https://m.workplace.com/WalesOnline/videos/cctv-footage-shows-a-fireball-meteor-flying-over-parts-of-wales/5242371693654 39/

In 2021 Netflix released a very popular film called 'Don't Look up' where 2 astronomers discover that a planet-killing comet is going to hit the earth in 6 months time and they try and warn everyone of the dire consequences….but is this possible and is it likely? This is what you will be investigating in this activity….

Scientists not only use observations to predict the behaviour or likelihood of events occurring, but they also use simulations – and impacts from space are no different. Scientists at Purdue University and Imperial College, London worked on coding the effects of what would happen if impactors of different masses, velocities and angles, hit the Earth, and for this activity, you will be using an online impact simulator which is based on this code, to investigate for yourself, what parameters affect how bad an impact from space could be….

In order to do our investigation, we will use the Down2Earth Impact Calculator. The Down2Earth Impact Calculator can simulate an impactor of a specific size and density, travelling at a certain velocity and given trajectory angle. Given the density of Earth rock that the impactor hits, this program can then simulate the effects which follow. The Impact Calculator can be found at the following here. http://simulator.down2earth.eu/ and instructions on how to use it can be found in the LaSciL toolbox.

You should familiarise yourself with the impact calculator before running your investigation, so that you know what all the parameters are and where the results are shown.

Hypothesis Generation and Design

Generation of Hypotheses or Preliminary Explanations

In this activity you are exploring the effects of impacts from space. But what do we need to think about to help us investigate this? What questions can you think of that you would like to answer? Take some time to think about possible questions and how this may form a hypothesis. Some example questions are given below:

- What parameters should we take into consideration when investigating asteroid/comet collisions?
- What happens when a piece of space rock/ice/metal hits the Earth?
- How often does this happen?
- What affects the size of the crater that these impacts create?
- Can we quantify the effects of a giant impact on our planet?

When generating your hypothesis, you must think of a question and then think of a way that you can test this in a fair way (which will be detailed in the next section).

An example hypothesis should contain a statement and then an explanation. For example, one hypothesis could be:

Larger sized objects make larger craters. This is because large objects have more mass and therefore have a larger kinetic energy and will therefore make a bigger crater on the Earth. This could be tested by running the impact calculator for a range of sizes, but keeping all other parameters the same. The size of the resulting crater can be measured and my hypothesis tested.

The above is a simple example, but starting off simple is a good idea, so let's try it now.

Planning and Investigating

Plan Investigation

Think of the question you want to answer - you should have written this down and thought about how you can test this (i.e. what parameters will you keep the same in your simulation and what will you change?)

For example, if you were investigating how the the size of an impactor affects crater size, you might want to think about the questions below:

a) How would you plan to do this?
b) What parameters would you change and what would you keep the same in the Impact Calculator?
c) For the parameter(s) that you would change, what increments would you use (i.e. in steps of 1, 2, 5, 10 etc.)?
d) What will you record? *(hint: think about what you are investigating).* Would it be useful to create a table to record your results?

Perform Investigation

Open the impact simulator (http://simulator.down2earth.eu/input.html?lang=en&planet=Earth) and carry out your investigation. Remember to record the parameters you are changing, what is staying the same, and your results, ready to analyse.

Analysis & Interpretation

Looking at the results in your table, did you notice a pattern emerge? How do your results fit with your hypothesis? In the example given above we hypothesised that a larger impactor would create a larger crater. Is this what your results tell you? How can you show this – you might want to plot a graph with your results – in this case, a plot of increasing impactor size vs. crater width/depth would help you draw any conclusions.

In the data view window of the impact calculator, more information is given regarding the energies involved in each simulated impact, as well as the frequency of such events. There is also information on what would happen on the Earth e.g. tsunamis, fires, destruction etc.

With this in mind – what conclusions can you draw about whether we should be worried about impactors of varying parameters hitting the Earth – what would be the worst/best for us? Think about this for the next section.

Conclusion & Evaluation

Conclude and communicate result/explanation

An important part of the scientific process is to communicate your results. Put together a poster or presentation that summarises and displays your methodology, results (including graphs) and conclusions of the activity.

At this point you might want to look at the various ideas that scientists have put forward for how they could mitigate any effects of impacts from space, or prevent them from happening altogether – this can be included in your presentation. A nice video to watch to help with this is linked below:

https://www.youtube.com/watch?v=rZk4GaO50K0

or you could read the following online article about the topic:

https://astronomy.com/news/2018/11/how-would-we-save-the-planet-from-a-killer-asteroid

You could also think about the following:

Did your conclusions match your predictions at the beginning?

What relationships did you identify?

What other investigations could you do?

What else might influence the size of impact craters?

Explain why it is important to simulate impacts from space and the steps you followed to do this. Include any discussions that took place in your classroom or from background research that you carried out.

Evaluation/Reflection

Comment on how well your investigation went. How accurate do you think the software is? Does it have any limitations? If you were to repeat this investigation, how would you improve it?

- Share your results with others in the class.
- Comment on any similarities/differences between your results and others.
- Think about how you individually carried out the activity and what you might change in future investigations which may affect your results.