Planetary Impacts

ROBERT GORDON'S COLLEGE

Researching Physics

Higher

Higher Physics

Researching Physics Planetary Impacts

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Overview of the unit and activities.

What is involved in the unit 'Researching Physics'?

Studying physics involves learning physics facts and concepts. It also involves developing particular skills. These include research skills, which may involve you in doing investigative experiments or researching information, perhaps from the internet. The aim of this unit is to help you develop these physics skills. You will learn some physics facts, probably in some depth, however it is the development of skills which is the focus of the unit.

What physics content will I be learning?

The context for your work is the study of planetary impacts and the factors affecting crater formation. The study of impact craters is an important aspect of astrophysics as it can give us an insight into the formation of the planets, their moons and the Solar System as a whole. Also, there is evidence of a previous large impact causing the mass extinction of the dinosaurs so an understanding of the consequences of a large impact on Earth is important to our survival as a species.
This pack includes details of investigations into factors affecting shape and size of the crater as well as the area of destruction around it.

What activities will I be doing?

There are three types of activities in the unit.

Undertaking literature based research is a hugely important skill. In this unit, this is best carried out as web-based research. It is easy to simply look up a single fact on the internet, but undertaking a more structured project is more complex. Sifting through what is often a large amount of data is demanding. Keeping track of what you are trying to find out is one of the most difficult parts of this type of research, and summarising what you have found, without merely cutting and pasting someone else's work is also challenging. There are several research briefs which can be used in preparation for your investigation.

Investigative practical work can be fun and challenging. Planning and designing experiments is often the hardest part of this work. Actually carrying out the experiment may be straightforward. The experiments you are likely to carry out in your investigation are not the kind where you can simply look up the results beforehand. There may be no right or wrong answers. What you find is what you find and your way of doing the experiment may not be similar to others in your class.

Scientific communication is hugely important. It does not matter how interesting or ground breaking your work is; if you cannot communicate your results then you have not completed your work. Information from your web research and data from your practical work will contribute to an assignment that you will complete under supervised conditions. This assignment is assessed externally by the SQA. You can pass this unit without completing the assignment, but you cannot get an overall course award in Higher Physics without doing so.

Organising your work and carrying out the activities

How will I organise my work?

Some of the work you carry out in this unit will be in preparation for your research into one or more aspects of exoplanets. When you carry out the research activities themselves, it is likely that you will be responsible for organising your work.

You are required to produce a report on the results of a piece of web-based research, and you may produce a report of your practical investigation that you may submit as your assignment for SQA assessment. You are strongly advised not to produce these “as you go along”. Rather, it is very good practice to maintain a diary, or record of work. This should record all your experimental results, ideas, problems you met, references and all the other day to day observations and data that you want recorded. The record of work is your record and as such it should be in a format that suits you. However, experience shows that students who organise their work for ease of reference are likely to be able to extract the information more easily and the resulting reports are likely to be easier to produce.

Will I do the same work as everyone else in my class?

This material includes a number of web-based research and practical investigation briefs. It is likely that students within the same class will be allocated different activities, depending on resources available and other classroom management issues.

What about teamwork?

It is probable that you will undertake some of the work as part of a group. Sometimes, within your team, you will be undertaking the same task and other times you will each focus on a different part of the task. In either case, it is important that discussion takes place. Agree the part that each member of the team will play and ensure that there is time to share the results of the work.

Assessment issues

What do I have to do to pass this unit?

As you work on this unit, you will carry out activities which develop your skills in undertaking research in physics.
Two of the activities contribute to the unit assessment. To be awarded the unit, you need to demonstrate that your work is of at least the required standard in each of the two types of activity.
The two types of activities are:

- Undertaking web based research
- Carrying out investigative practical work - you need to take an active part in planning and carrying out an investigation.

Do I need evidence?

For the web based research and scientific communication, you should ensure that you retain evidence that your work is of the required standard. Each year SQA will ask to see the evidence from a number of candidates. This process is easiest to manage if your evidence is stored in an e-portfolio. You can store text based work, together with pictures, web pages, and any other material which you wish to present as evidence. If you do not use an e-portfolio, you should ensure that your evidence can be easily accessed.

What about assessment in the Higher Physics exam?

The Higher unit - Researching Physics is available as a free standing unit. It is also a required unit for a course award in Higher Physics. There will not be any questions in the Higher Physics course assessment which specifically relate to the topic of this unit. However, there will be questions in the course assessment which relate to the skills that you have developed in the unit. The following are the skills which may be assessed in the course assessment:

- Selecting information from texts, tables, charts, graphs and diagrams,
- Presenting information in a variety of forms,
- Processing information,
- Planning and designing an experiment,
- Evaluating experimental procedures,
- Drawing conclusions and making predictions based on evidence provided.

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Initial Research Activity

Meteorites – What are they?

Research Brief

In the early 1600s Galileo Galilei deduced by telescope observation that the shadows on the Moon were due to topographical landforms such as mountains and craters. This dispelled the long held view that the celestial bodies were perfectly smooth and without flaw. It is now known that these craters, also evident on most of the solid-surfaced planets and satellites, are due to impacts on the surface by an object originating from somewhere else in the Solar System. Over the past few decades, the study of planetary impacts has escalated with the advent of space travel and it has become apparent that space impacts are a major source of information on the formation of the terrestrial planets and their satellites.

In this initial research activity you will find out some background information about meteorites and their origins.

In carrying out your research you should answer the following questions.

- What is difference between an asteroid, comet, meteorite, meteoroid and meteor?
- Where do they come from?
- What types of meteorites are there?
- How old are meteorites?
- What can studying the chemical composition of meteorites tell us?
- Where are meteorites found and why?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

You should spend approximately 2 hours on this activity.

If you work as part of a team that produces one report, you should include a short statement at the end of the report that indicates which part of the work you were responsible for.

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Research Activity 1

Impact Craters – Formation Factors

Research Brief

Impact craters are evident on most of the solid-surfaced planets and satellites in our Solar System. The study of craters can provide information on the formation and history of the celestial body.

In carrying out your research you should answer the following questions.

- Are all craters created by impacts? What evidence can help us decide?
- What is an impact event and impact crater?
- What are the processes of crater formation?
- What factors affect the size and shape of a crater?
- Does a planet's atmosphere influence cratering?
- What factors effect erosion of craters?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

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Research Activity 2
Strikes on Earth – Past and Future Dangers

Research Brief

The number and distribution of crater sites varies amongst planetary and satellite surfaces e.g. there is a high density of craters visible on the Moon but very little evidence on Earth. Impacts on Earth do occur and could have affected the evolution of life and potentially a future strike could dramatically alter life as we know it.

In carrying out your research you should answer the following questions.

- Why is the study of craters on Earth important?
- How often do impacts occur on Earth and why it is difficult to tell?
- What are the most well-known craters visible on Earth today and where are they located?
- Are impacts more destructive on land or water?
- Do meteorite strikes pose a greater risk to life than other natural phenomena?
- What systems do we have to enable prediction of potential future impacts?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

You should spend approximately 2 hours on this activity.

If you work as part of a team which produces one report, you should include a short statement at the end of the report that indicates which part of the work you were responsible for.

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Practical Activity 1

Seismometers and energy released in an impact

Investigation Brief

Impacts release an enormous amount of energy which is transmitted away from the initial point of impact by intense vibrations or seismic waves. The amount of energy that is released determines the maximum amplitude of the vibrations.

The aim of this investigation is to compare the energy of an impact with the maximum amplitude of the seismic waves.

In the laboratory, an impact can be simulated by dropping a mass onto a surface. The resulting vibrations can be detected with a model seismometer.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work. What do you think is the relationship between the energy of the impact (falling mass) and the maximum amplitude of vibration?

Investigation Notes

A seismometer is a measuring device that detects vibrations. Almost all seismometers are based on the principle of inertia. A suspended mass tends to remain still when the ground moves. One kind of model seismometer uses a magnet as the suspended mass. The magnet is attached to a metal arm and held inside a coil of wire which is in contact with the ground or bench. As this surface vibrates, the coil vibrates. This movement, relative to the magnet, produces a small voltage which can be measured. By connecting the output from the coil to the microphone input of a computer, software can be used to analyse the voltage and hence the amplitude of vibration of the coil.

Audacity is one computer software package that can be used to analyse the voltage produced by the coil. You may need to spend some time familiarising yourself with it before carrying out the investigation.

It will be necessary to give some thought to how many times the experiment should be repeated. Also, you should give careful consideration to how you will present your results.

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Practical Activity 2A

Factors affecting the shape and size of an impact crater – mass of meteorite.

Investigation Brief

When a meteorite is large enough to reach the surface without being destroyed by the atmosphere, a crater will be formed if it strikes a solid surface i.e. on land. There are many factors that affect the size and shape of the impact crater that is formed during this impact.

The aim of this investigation is to use a model meteorite and planetary surface to investigate the relationship between the crater shape and size and the mass of the meteorite.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work. What do you predict will happen to size and shape of the crater as the mass increases?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory although it will be necessary to obtain a suitable amount of sand. It may be useful to carry out some preliminary work to find the best depth of sand.
It will be necessary to give some thought to how many times the experiment should be repeated to enable the results to have statistical significance. Also, you should give careful consideration to how you will analyse and present your results.

After the meteorite strikes the surface you should carefully remove the mass and measure the depth, diameter and sketch the shape of the crater.

Questions for consideration:
At what height will you drop the meteorite from?
What shape of meteorite will you use?
How many different masses of meteorites will you use?
How many times will you measure the diameter and depth of the crater for each mass of meteorite?
What will you do to control all the other variables in the investigation?
How will you present your findings?

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Practical Activity 2B

Factors affecting the shape and size of an impact crater – surface type.

Investigation Brief

When a meteorite is large enough to reach the surface without being destroyed by the atmosphere, a crater will be formed if it strikes a solid surface i.e. on land. There are many factors that affect the size and shape of the impact crater that is formed during this impact.

The aim of this investigation is to use a model meteorite and planetary surface to investigate the relationship between the crater shape and size and the type of surface.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work. What do you predict will happen to size and shape of the crater as the surface type changes?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory although it will be necessary to obtain a suitable amount of different surface materials. It may be useful to carry out some preliminary work to find the best surface types.
It will be necessary to give some thought to how many times the experiment should be repeated to enable the results to have statistical significance. Also, you should give careful consideration to how you will analyse and present your results.

After the meteorite strikes the surface you should carefully remove the mass and measure the depth, diameter and sketch the shape of the crater.

Questions for consideration:
At what height will you drop the meteorite from?
What mass and shape of meteorite will you use?
How many different surface types will you use?
How many times will you measure the diameter and depth of the crater for each surface type?
What will you do to control all the other variables in the investigation?
How will you present your findings?

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Practical Activity 3

Immediate danger zone and energy of impact

Investigation Brief

When a meteorite is large enough to reach the surface without being destroyed by the atmosphere, it is not only the impact site that is affected but a large area surrounding the impact site. During the collision, a large volume of molten rock and debris is projected into the air and away from the impact site. This is known as *ejecta* and the ejecta is spread across a large area causing widespread damage.

The aim of this investigation is to use a model meteorite and planetary surface to investigate the relationship between the area of the ejecta zone and the energy of the impact.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work. What do you predict will happen to the area of the ejecta zone as the energy of the impact increases?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory although it will be necessary to obtain a suitable amount of your chosen surface materials. It may be useful to carry out some preliminary work to find the best surface type.
It will be necessary to give some thought to how many times the experiment should be repeated to enable the results to have statistical significance. Also, you should give careful consideration to how you will analyse and present your results.

After the meteorite strikes the surface you should carefully sketch the shape of the ejecta pattern and measure the maximum distance the ejecta travelled.

Questions for consideration:
At what height will you drop the meteorite from?
What mass and shape of meteorite will you use?
How many times will you measure the distance the ejecta travelled?
How many times will your repeat your impact?
What will you do to control all the other variables in the investigation?
How will you present your findings?

The exemplars given in this pack are only a selection of possible experiments that could be conducted by pupils which would provide a suitable standard of investigation.

Examples of other possible investigations that could complement/replace those provided in Practical activity 1:

- Using seismometer to investigate energy vs distance from impact (see RP Earthquakes for further guidance)
- Using seismometer to investigate location of impact site (see RP Earthquakes for further guidance)

Examples of other possible investigations that could complement/replace those provided in Practical activity 2:

- Height of drop (energy) vs radius/shape/depth of crater
- Material of model meteorite vs radius/shape/depth of crater
- Velocity of meteorite vs radius/shape/depth of crater
- Angle of launch vs radius/shape/depth of crater
- Wetness of surface type (mixing sand and water) vs radius/shape/depth of crater
- Surface area of meteorite base vs radius/shape/depth of crater

Suggestions for surface types include different types of sand (builders, playpark, mixed etc.), different types of sugar (granulated white, caster, brown, muscovado, demerara etc.), different types of flour (corn, plain, self-raising etc), clay, flour and water paste.

Examples of other possible investigations that could complement/replace those provided in Practical activity 3:

- Height of drop (energy) vs ejecta distance/mass of ejecta
- Material of model meteorite vs ejecta distance/mass of ejecta
- Velocity of meteorite vs ejecta distance/mass of ejecta
- Angle of launch vs ejecta distance/mass of ejecta
- Wetness of surface type (mixing sand and water) vs ejecta distance/mass of ejecta
- Surface area of meteorite base vs ejecta distance/mass of ejecta

Possible experiment set up (very easy to reset and repeat): Tray of sand covered with black card so ejecta is easily identified. A hole is cut in centre of card into which the model meteorite is dropped. Ejecta distance can then be easily measured. Mass can be measured, if required, by carefully lifting card and pouring displaced sand into a tray on a zeroed top pan balance.
Another possible method is to use flour/sugar covered with thin layer of cocoa/cinnamon. The contrast provides easily measured distances but mass will not be able to be measured. It is also more difficult to set up experiments for repeats easily.

List of potential websites and sources

"The hazard of near-Earth asteroid impacts on earth"
Clark R. Chapman, Earth and Planetary Science Letters 222 (2004) 1 –15

http://sentinelmission.org/
The Sentinel Mission team is a collaboration of the world's leading space scientists who, above all, listen to the data. Answering the asteroid challenge requires a complex and perfect scientific solution, and we have the right team to meet that challenge. We're proud to say that our team continues to grow with some of the best minds that have ever designed, launched and managed numerous space missions.

"METEOR IMPACTS AS A SEISMIC SOURCE ON MARS**"** N. A. Teanby, J. Wookey, School of Earth Sciences, University of Bristol, UK (n.teanby@bristol.ac.uk). 43rd Lunar and Planetary Science Conference (2012)

http://www.passc.net/EarthImpactDatabase/IntrotoImpacts.html
Impact Cratering on Earth – Earth Impact Database, Planetary and Space Science Centre, Department of Earth Sciences, University of New Brunswick,

http://www.nytimes.com/2006/11/14/science/14WAVE.html?pagewanted=all&_r=0
"Ancient Crash, Epic Wave", Article in the Science Section of the New York Times

http://impact.ese.ic.ac.uk/ImpactEffects/
Earth Impact Effects Program *A Web-based computer program for calculating the regional environmental consequences of a meteoroid impact on Earth.* (Imperial College London / Purdue University)

http://neo.jpl.nasa.gov/risks/
Near Earth Object Program, NASA