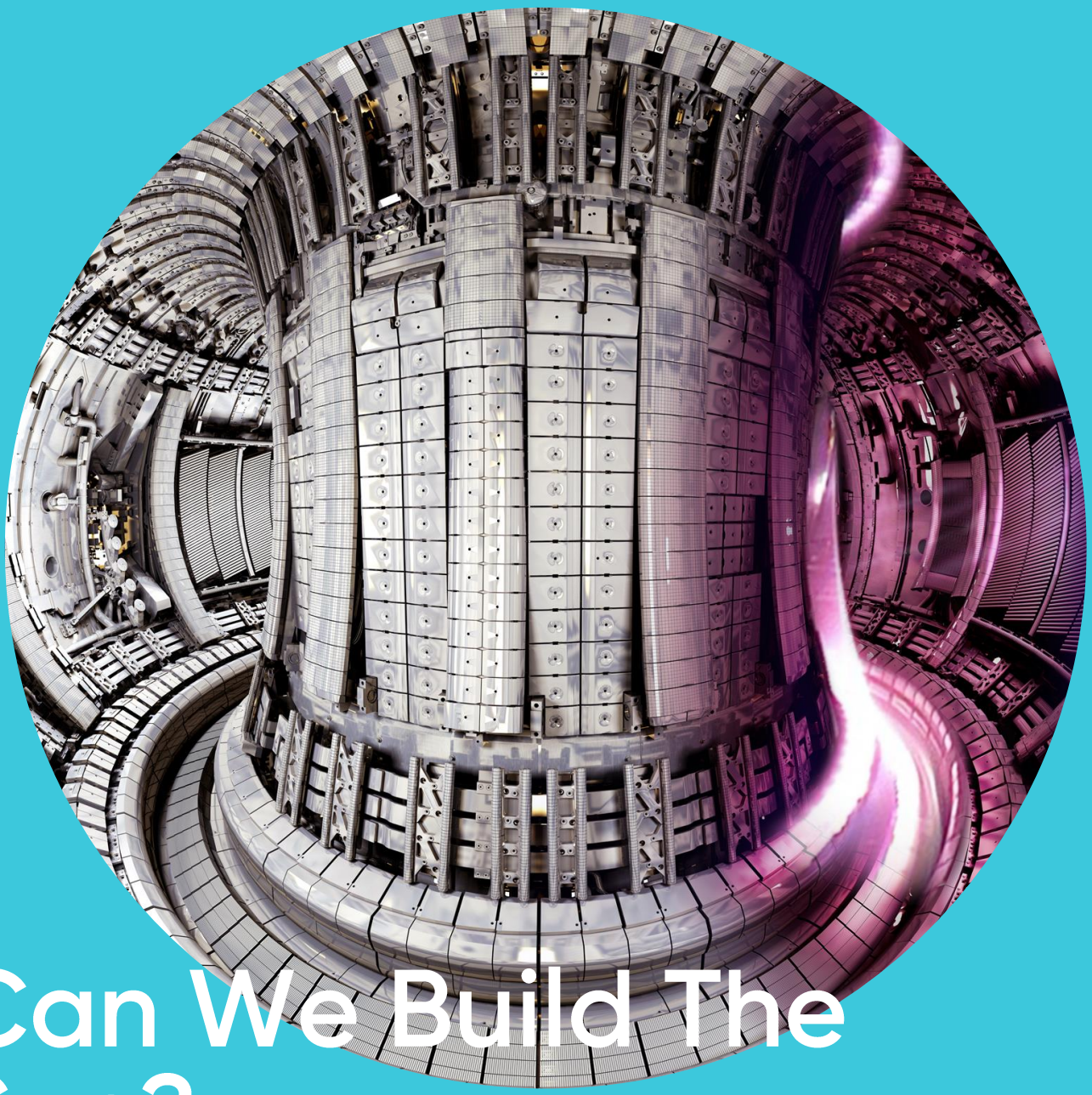

Can We Build The Sun?

Key Stage 4 Programme

Pupil Name

Handbook Designed by Dr Murphy-Sugrue

Timetable and Assignment Submission

Timetable – Tutorials

1			
2			
3			
4			
5			
6 (Feedback)			

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on 9th August	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

The Brilliant Club KS5 Programme – Pupil Feedback Report

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

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor	Dr Murphy-Sugrue		
Title of Assignment	Can We Build the Sun		
Name of Pupil			
Name of School	Therfield School		
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

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

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

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Tutorial 3 **P23**

Activity 1 **P23**

Activity 2 **P24**

Activity 3 **P25**

Homework Assignment 3 **P27**

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Activity 1 **P29**

Activity 2 **P30**

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Course Rationale

Can we harness the unlimited energy of an Earth-bound Sun? This is the question scientists have been asking for over 60 years. Can we heat atoms to 100's of millions of degrees and reproduce the conditions inside a star? Can we then use this miniature Sun to generate unlimited amounts of clean electricity? Once the answer to these questions is yes, humanity will have reached a historic moment.

Can we build the Sun is a course that will allow students to build upon their existing knowledge of climate change whilst gaining knowledge of nuclear fusion – the process that powers the Stars. They will learn about plasma – the 4th state of matter and how to use Einstein's famous equation $E = mc^2$. Students will learn about the successes of nuclear fusion and explore the areas that are at the cutting edge of research carried out by scientists all over the world in order to build a star on Earth.

The final assignment will involve identifying a prominent area of fusion research and allow students to put into practise key skills used by all modern scientists. Students will produce a fully referenced letter based on the knowledge they have acquired over the course, demonstrating why fusion research is so vital to future human generations.

Mark Scheme Table

	Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Subject knowledge	Knowledge and Understanding	○ All content included is relevant to the general topic and to the specific question/title ○ Good understanding of all the relevant topics. ○ Scientific terms are defined and used accurately throughout ○ Clear justification on how the content included is related to the specific issues that are the focus of the assignment	○ Most of the content included is relevant to the general topic and to the specific question/title ○ Good understanding of most the relevant topics ○ Scientific terms are used accurately but not always clearly defined. ○ Adequate justification on how the content included is related to the specific issues that are the focus of the assignment	○ Some of the content included is relevant to the general topic and to the specific question/title ○ Good understanding on some of the relevant topics but occasional confusion on others. ○ Scientific terms are used mostly accurately with occasional confusion and often not defined. ○ Some justification on how the content included is related to the specific issues that are the focus of the assignment
Critical thinking	Research and Evidence	○ Inclusion of rich sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/calculations to support claims/assertions /ideas, consistently clearly and convincingly ○ Evidence of further reading beyond materials provided which were used in an appropriate context ○ Data is effectively analysed and appropriate assumptions/conclusions are reached	○ Inclusion of adequate sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/calculations to support claims/assertions/ideas, mostly clearly and convincingly ○ Evidence of further reading beyond materials provided ○ Data is analysed and the assumptions/conclusions that are reached are mostly appropriate	○ Inclusion of some sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/calculations to support claims/assertions/ideas, at times clearly and convincingly ○ Limited evidence of further reading beyond materials provided ○ There is an attempt to analyse data is and draw assumptions/conclusions
	Developing an Argument	○ A point of view or position in relation to the title or question is	○ A point of view or position in relation to the title or question is	○ A point of view or position in relation to the title or question is

		consistently clear ○ Argument/proof exceptionally well-developed and well-justified ○ A position is clearly established in relation to the question, and is developed effectively and consistently throughout the essay ○ Makes links effectively between subjects that have not previously been associated ○ Uses concepts from the tutorials in an unfamiliar context, and does so accurately and confidently. ○ Content is analysed effectively to support the argument	adequately clear ○ Argument/proof clear and well-developed and position justified ○ A position is established in relation to the question, and is well-developed in most of the essay ○ Some evidence of linking subjects that have not previously been associated ○ Use some concepts from the tutorials in an unfamiliar context, but not always accurate ○ Analysis of content to support the argument	somewhat clear ○ Argument/proof clear but not well-developed ○ A position is established in relation to the question, and is well-developed in parts of the essay ○ Limited evidence of linking subjects that have not previously been associated ○ Limited use of concepts from the tutorials in other contexts ○ Some analysis of content to support the argument
	Critical Evaluation	○ Moved beyond description to an assessment of the value or significance of what is described ○ Evaluative points are consistently explicit/systematic/reasoned/justified ○ Effective critiques on the reliability of sources provided	○ Mostly description but some assessment of the value or significance of what is described ○ Evaluative points are mostly explicit/systematic/reasoned/justified ○ Some evidence of critiques on the reliability of sources provided	○ Only description with minimal assessment of the value or significance of what is described ○ Evaluative points are at times explicit/systematic/reasoned/justified ○ Limited evidence of critiques on the reliability of sources provided
Written communication	Structure and Presentation	○ Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment ○ The introduction clearly outlines how the essay/report will deal with the issues ○ The conclusion summarises all the main points clearly and concisely	○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment ○ The introduction adequately describes how the essay/report will deal with the issues ○ The conclusion summarises most of the main points clearly ○ Calculations,	○ Ideas are presented in paragraphs and arranged in a structure ○ The introduction mentions how the essay/report will deal with the issues ○ The conclusion summarises some of the main points clearly ○ Calculations, formulas and methods are not always structured, clear to follow

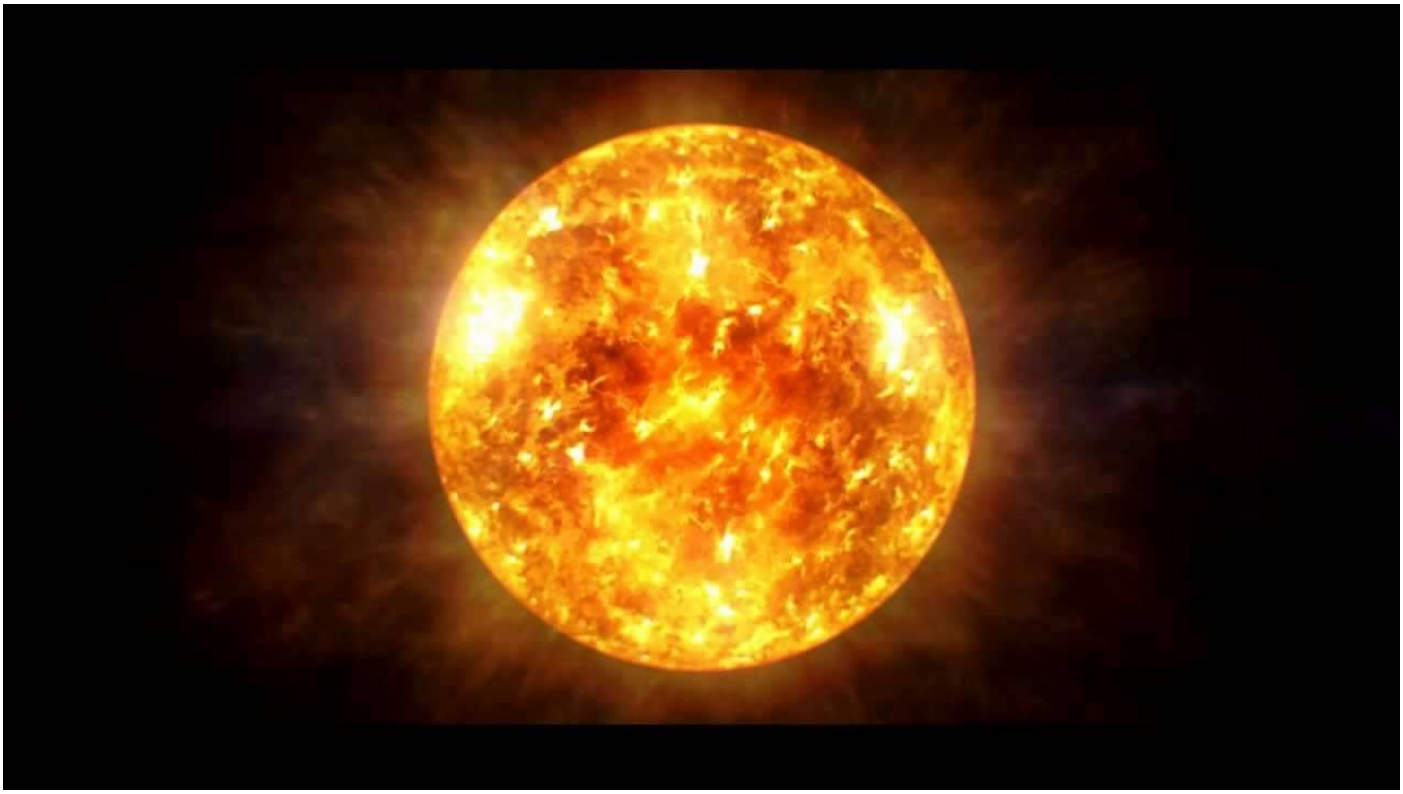
		○ All calculations, formulas and methods are clearly structured, clear to follow and correct ○ Tables and graphs are effectively constructed including appropriate headings, units and scales. ○ All sources are referenced correctly in an agreed format	formulas and methods are mostly structured, clear to follow and correct ○ Most tables and graphs are well constructed ○ Most sources are referenced correctly in an agreed format	and correct. ○ Some tables and graphs are well constructed but contains some errors ○ Some sources are referenced correctly in the agreed format with occasional errors
	Language and Style	○ No spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style consistently clear, appropriate for scientific documents and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ Minimal spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style mostly clear, appropriate for scientific documents and easy to follow ○ Some attempts of using technical language and vocab alary, but not always accurate	○ Some spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout with occasional errors ○ Writing style moderately clear, appropriate for scientific documents and easy to follow ○ Use of simple language and vocabulary effectively but struggles to use technical language

Glossary of Keywords

Word	Definition	In a sentence
Intermittent		Renewable energy sources are intermittent
Fission	The splitting of large nuclei into smaller nuclei	Fission of uranium produces energy in nuclear power plants
Fusion		Nuclear fusion is the process that powers the stars
Greenhouse Gas		
Fossil Fuel		
Isotope		
Ion		
Mass Defect		
Atom		
Ionised		
Nucleus		
Plasma		
Solenoid		

Self Sufficient		
Tokamak		
Toroidal		
ITER		
Breeder Blanket		

Tutorial 1 – What Makes a Perfect Energy Source?



What is the Purpose of Tutorial 1?

- To review the current sources of energy that power our homes, cars and technology
- To explain the greenhouse effect
- To describe properties of the perfect energy source

Give examples of electricity usage in everyday life:

Label the sources of energy below. For each source state whether it is a renewable or non-renewable energy source:

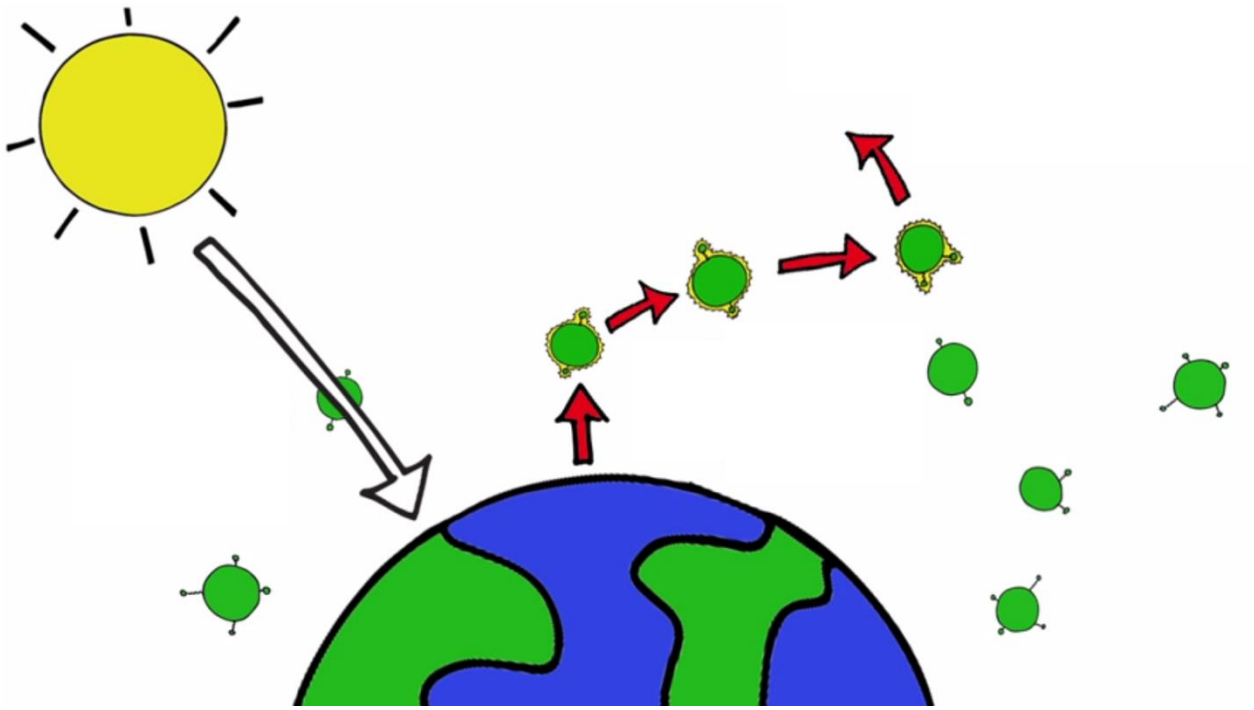
_____ _____

_____ _____

Write down the advantages and disadvantages of the different sources of energy:

Form of Energy	Advantages	Disadvantages
Fossil Fuels		
Renewables		
Nuclear Fission		

Watch the video shown in class. Label the arrows on the following diagram:



What is a greenhouse gas? Give two examples:

Why does increasing the concentration of greenhouses gases in the Earth's atmosphere cause the planet to warm up?

List the properties a perfect source of energy must have:

Property	Why This is Important

Additional Notes

Tutorial 1 – Baseline Assignment

In 100-200 words explain why the burning of fossil fuels results in an increase in the Earth's temperature. Your answer should include the greenhouse effect.

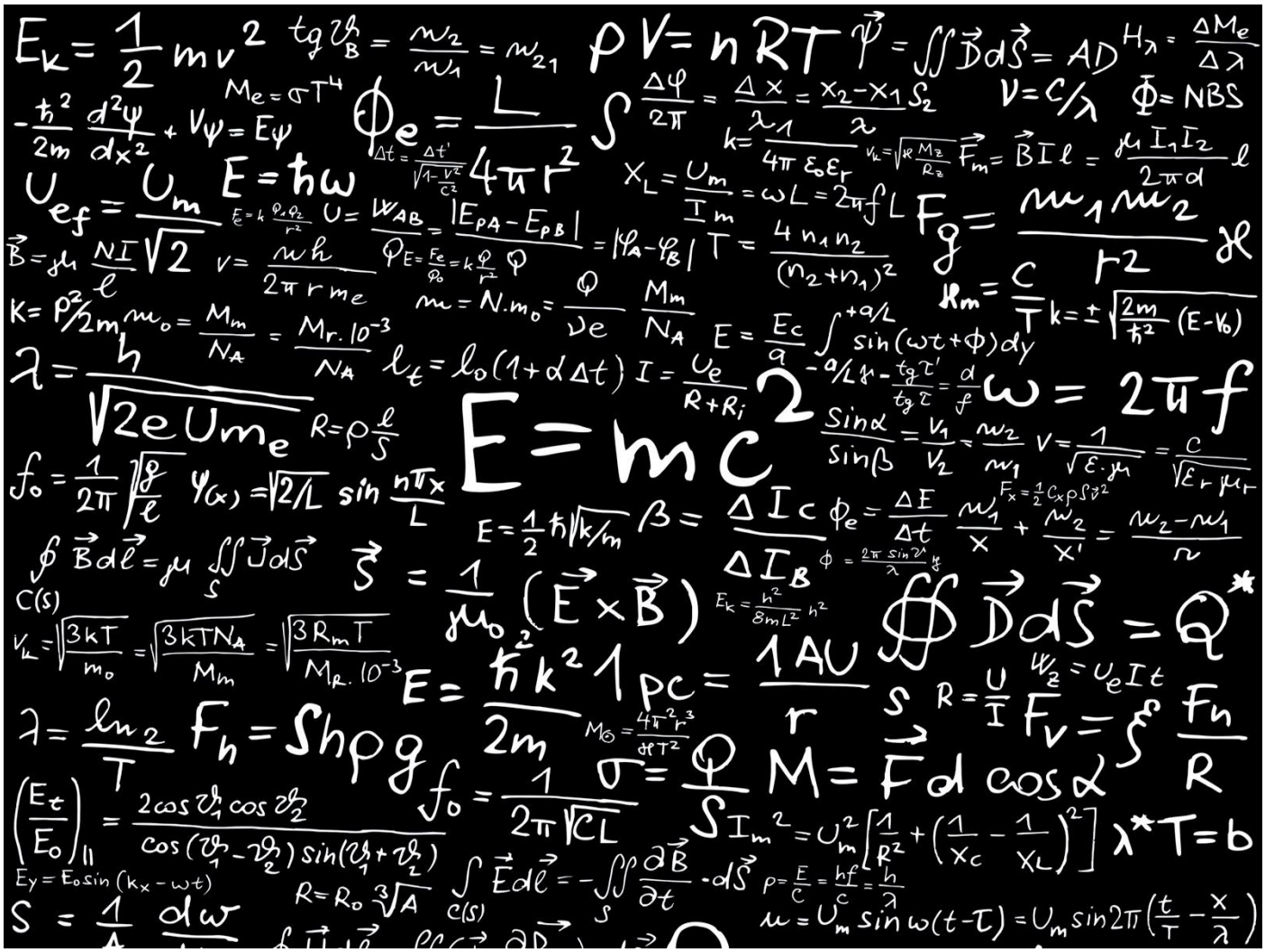
Read the first page of Chapter 24 "Nuclear?" from the book *Sustainable Energy – Without the Hot Air"*. The book can be downloaded on the website https://www.withouthotair.com/download.html for free:

Describe the differences between nuclear fission and nuclear fusion. Which advantage, described in the text, do nuclear energy sources have over conventional energy sources? Think about what happens to the atoms in both types of reaction: explain the difference between a nuclear source of energy and a chemical source of energy. Give one example of each type. Your answer should be 100-200 words long. Make sure to reference the book as your source of information.

How many kilograms of fossil fuels would the average person need for their entire annual supply of energy?

How many grams of uranium would the average person need for the entire year supply of energy?

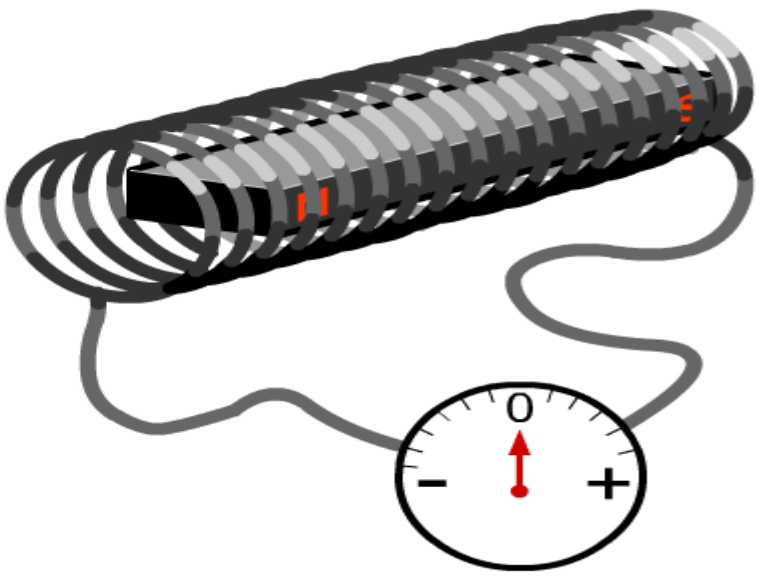
Tutorial 2 – Using Atoms to Make Electricity



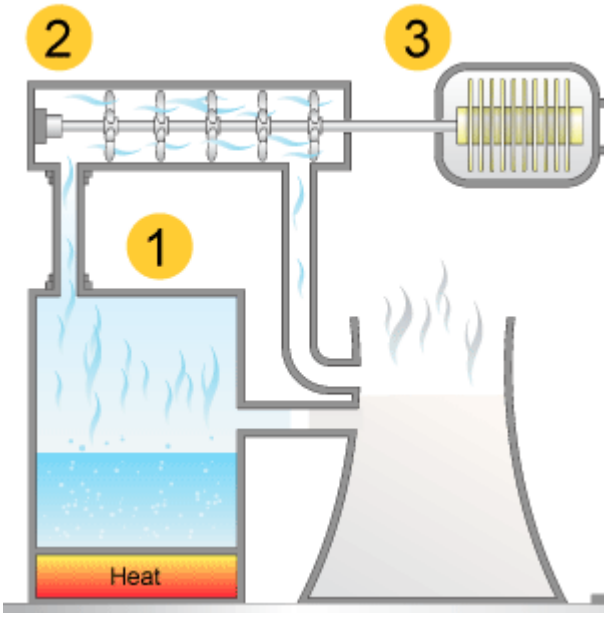
What is the Purpose of Tutorial 2?

- To understand how power stations generate electricity
- To introduce the equation $E = mc^2$
- To detail the key fusion reactions

After the demonstration, describe what happens to the ammeter reading once the magnet is moved out of the coil. Is there a difference when the magnet is instead moved into the coil?



Describe the energy transfers that are happening in the following diagram:

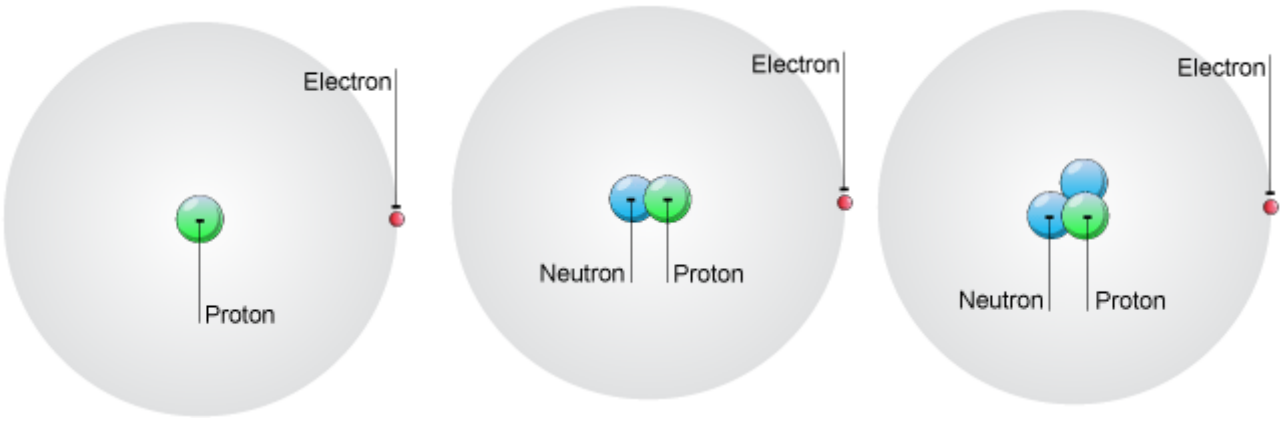


Einstein showed that mass and energy are equivalent in his famous equation $E = mc^2$. In the chemical reaction of burning coal in oxygen, we produce carbon dioxide and energy. 1 kg of coal releases 24 MJ of energy when burned.

Calculate how much energy 1 kg of coal would release if we could convert all of its mass into energy. What percentage of this energy is released in the chemical reaction of coal?

Describe what is meant by the mass defect:

Explain what an isotope is and complete the chemical symbols and names for the three isotopes of hydrogen:

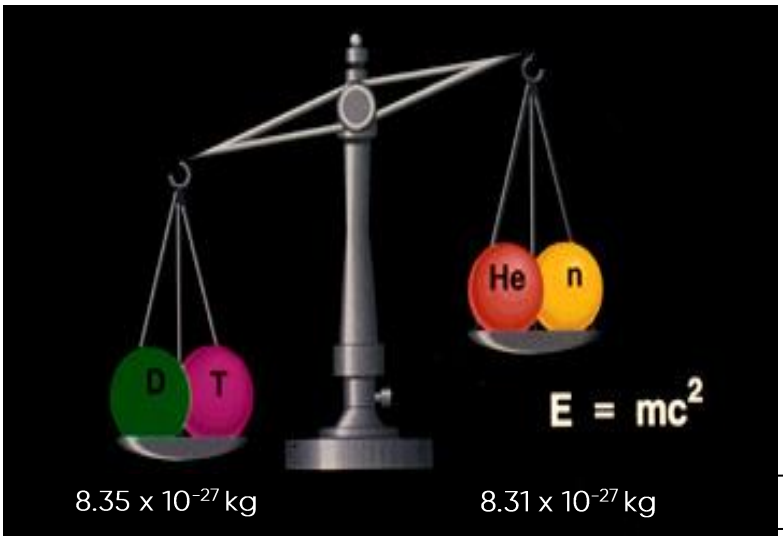


$^{1}H_{1}$ H_{1} ^{3}H

Hydrogen Deuterium

Calculate the mass defect for the following reaction. Use this mass defect to determine the energy released:

$$^{2}H_{1} + {}^{3}H_{1} = {}^{4}He_{2} + {}^{1}n_{0}$$



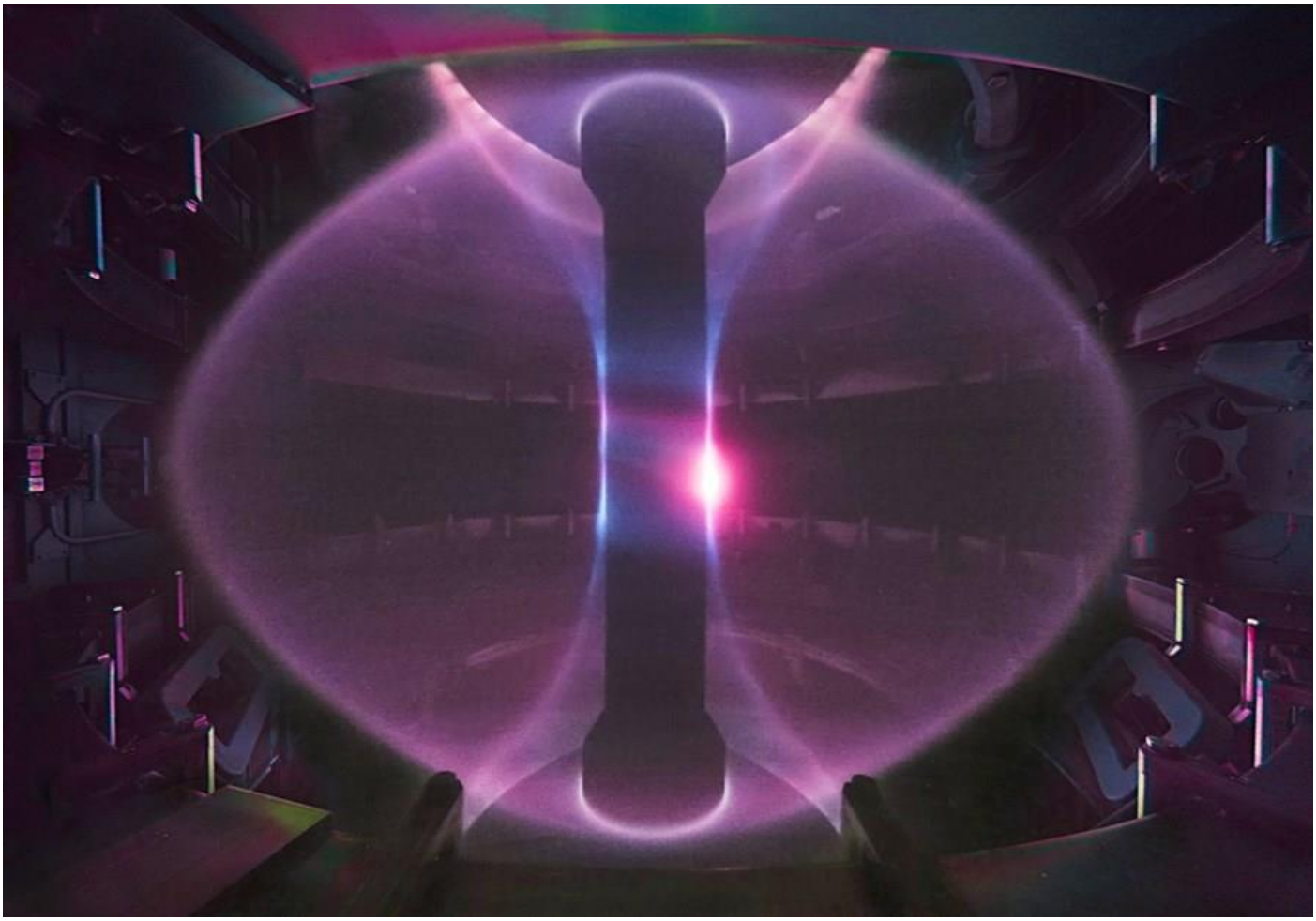
Additional Notes

Tutorial 2 – Homework

The equation above is the key reaction that scientists all over the world are using to produce fusion energy. The energy released by the nuclear reaction is given to the helium nucleus and the neutron in the form of kinetic energy. 80% of the energy is given to the neutron with the remaining 20% given to the helium nucleus.

Read this page from the following website http://www.ccfe.ac.uk/How_fusion_works.aspx. Beginning with the mass of the hydrogen isotopes being converted into kinetic energy, describe how fusion generates electricity. Make sure to mention the key energy transfers that take place. Answers no more than 300 words. Make sure to reference the website.

Tutorial 3 – Plasma : The 4th State of Matter

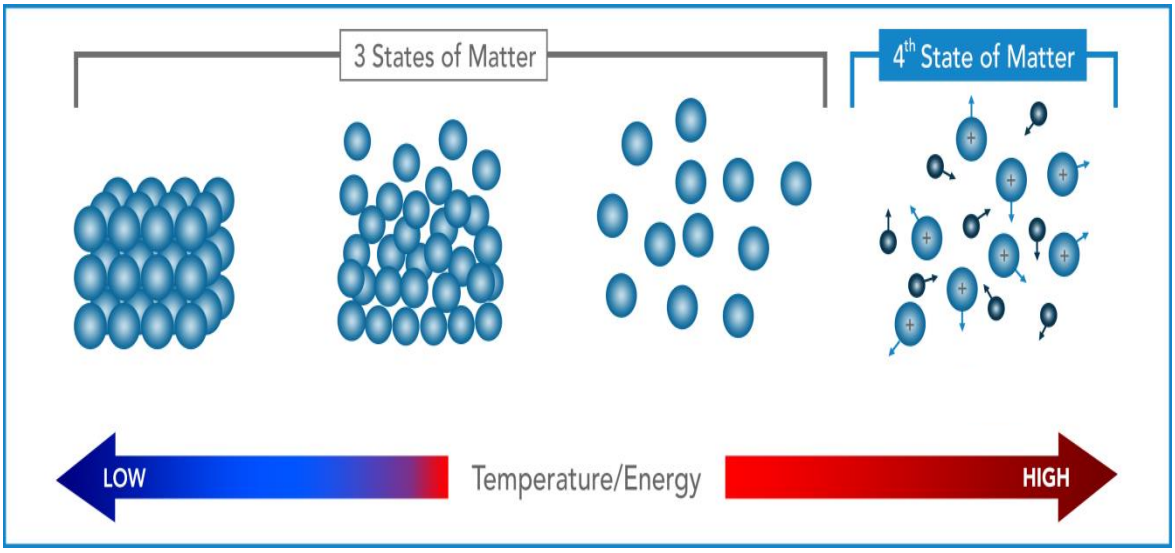


What is the Purpose of Tutorial 3?

- To explain why fusion is so hard to achieve
- To introduce plasma
- To demonstrate how plasma responds to magnetic fields

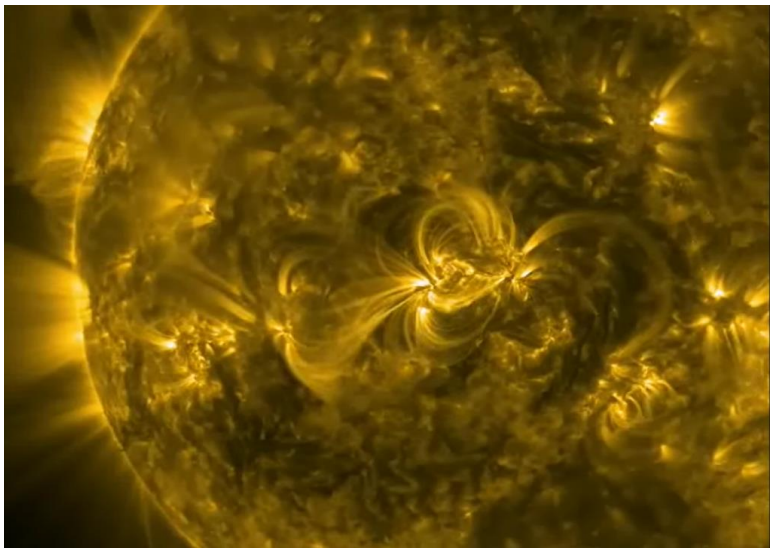
After the demonstration complete the question, Why are high temperatures required for fusion to occur? Your answer should include a diagram of two magnets and two positively charged nuclei:

Label the four states of matter and add the correct charge to the electrons:

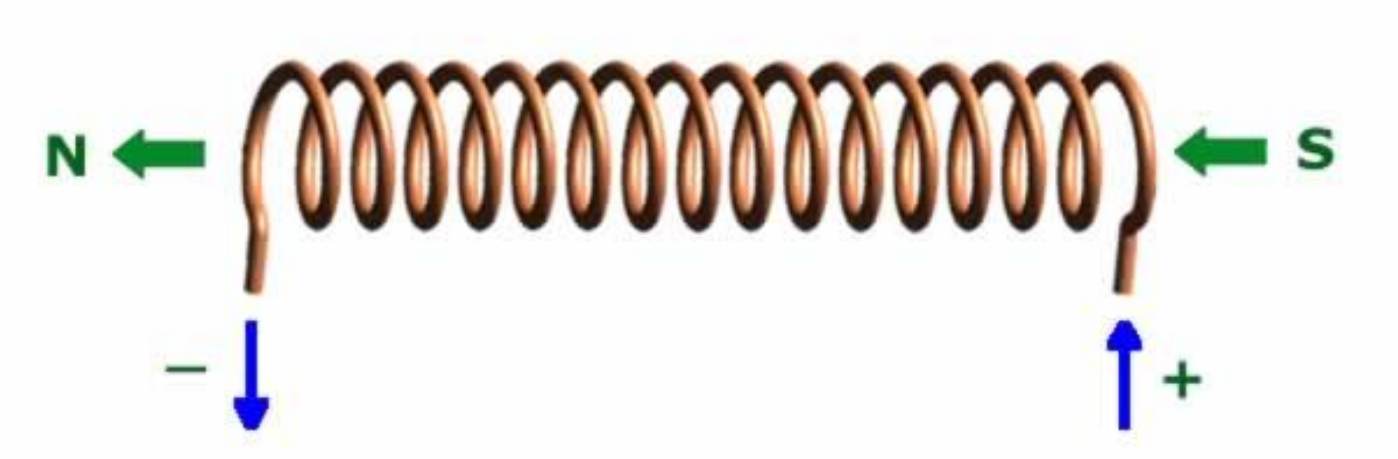


What is a plasma and why does it form at high temperatures? How is it different from a gas?

Watch the video. How does the Sun confine the plasma? What is the biggest challenge scientists face with nuclear fusion on Earth?

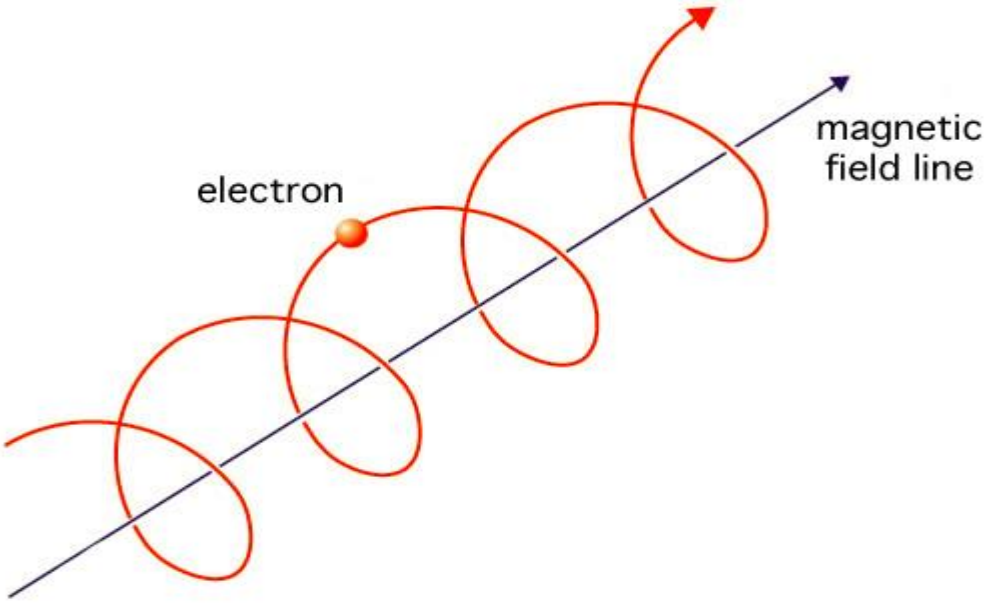


Complete the diagram of the solenoid by adding the magnetic field lines



What is a solenoid?

Watch the animation. How does the charged particle respond to the magnetic field?



Additional Notes

Tutorial 3 – Homework

The tokamak is the most successful fusion device that scientists have ever built. Multiple tokamaks exist around the world, the largest is found in Oxford, it called JET and is less than 50 miles from here. We will be learning more about this machine in the next tutorial.

The tokamak traps the charged particles of the plasma using a magnetic cage. Use the interactive diagram on this website to explore how this occurs. http://www.ccfe.ac.uk/tokamak.aspx

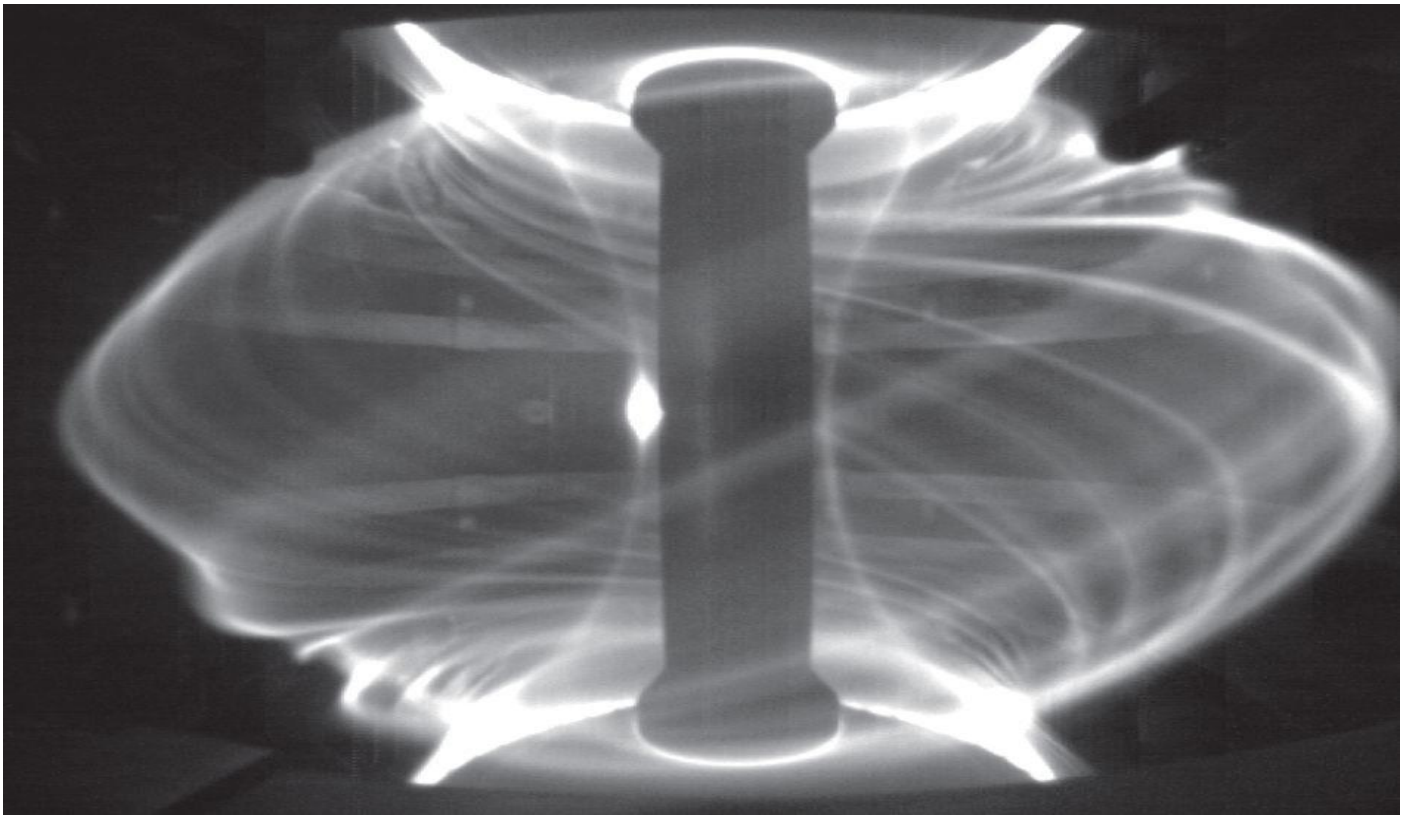
In roughly 100 words for each part, answer the following questions:

a) What happens to the charged particles when both the plasma current and the magnets are off?

b) What happens to the charged particles once the magnets are turned on? How does this field compare to that of the solenoid?

c) What happens to the magnetic field lines once the plasma current is also turned on? What effect does this have on the charged particles?

Tutorial 4 – Capturing the Sun in a Magnetic Bottle

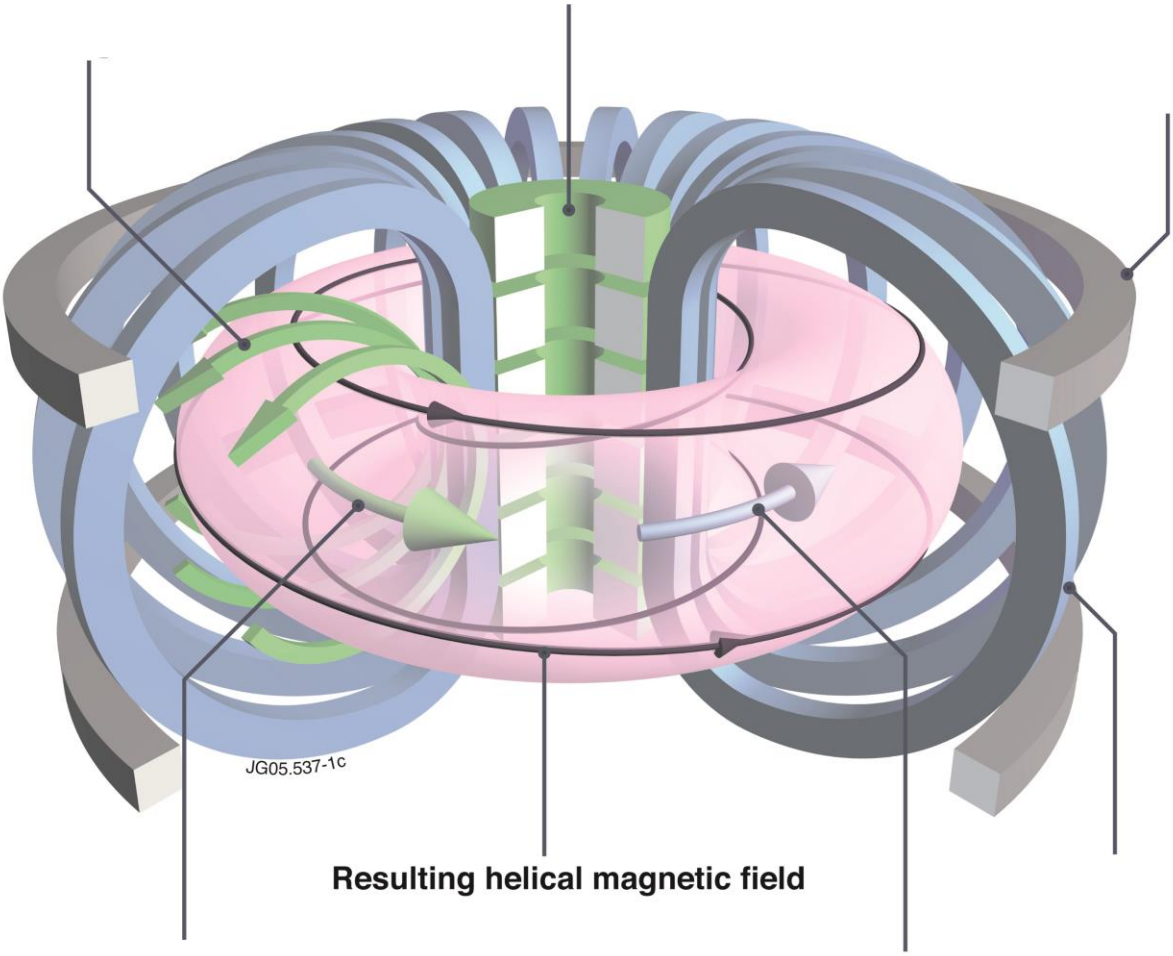


What is the Purpose of Tutorial 4?

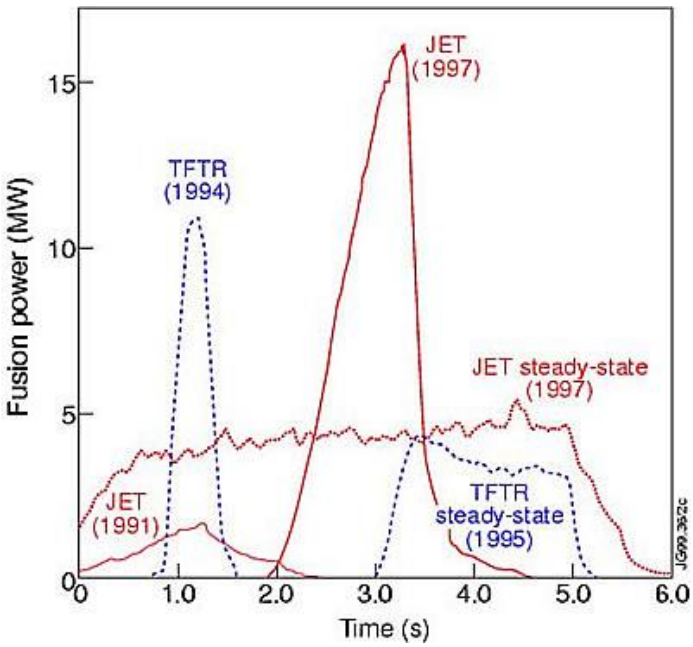
- To explain how a tokamak confines plasma
- To demonstrate the successes of the tokamak design
- To introduce the problems scientists must overcome

After the demonstration explain how the plasma current creates a magnetic field. What is the shape of the resulting magnetic field in the tokamak?

Label the parts of the tokamak and the magnetic fields:



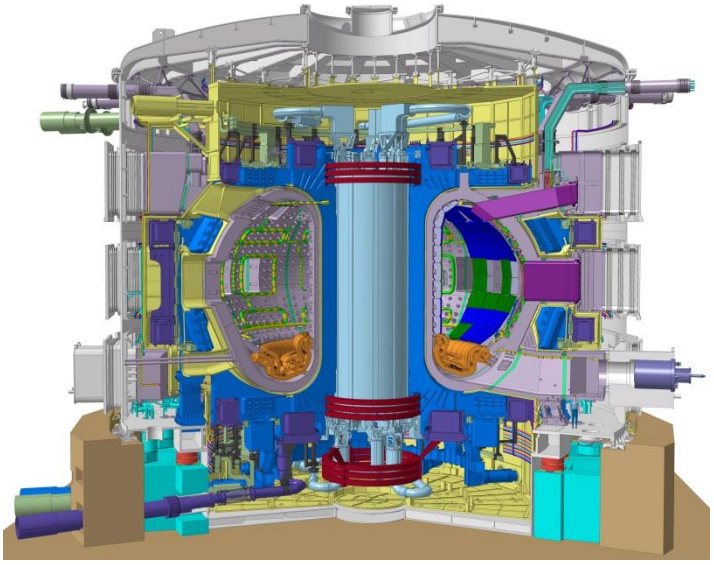
What is the peak power output from JET? How many PS4's could this power?



Why does this result demonstrate fusion is not yet suitable for a power plant?

Make notes from the lecture "Fusion Progress Since 1997"

What is ITER and what are its main aims?



Additional Notes

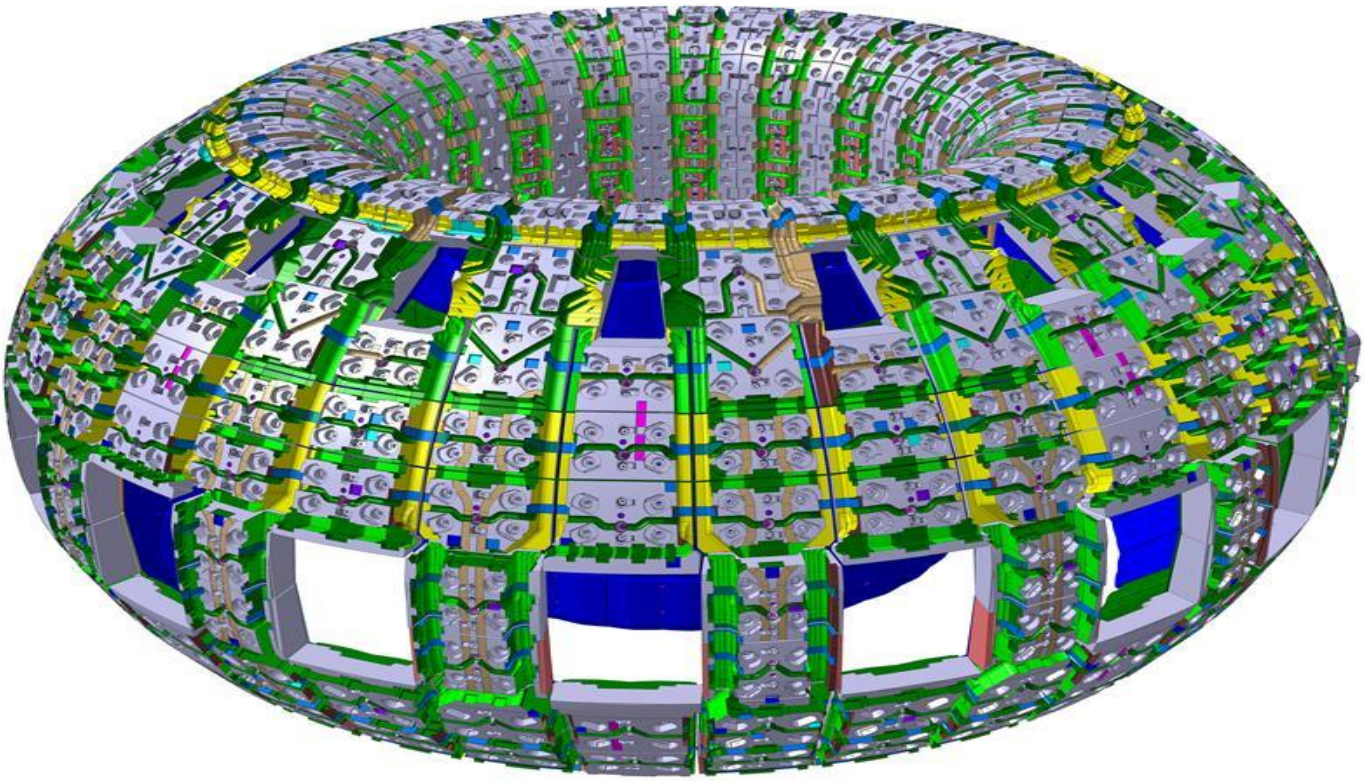
Tutorial 4 – Homework

Read the following website https://www.iaea.org/newscenter/news/fusion-energy-future . Why are deuterium and tritium used for fusion on Earth?

Read the following article about deuterium and tritium https://www.iter.org/mach/tritiumbreeding . Describe the problems fusion will face in the future, posed by this article. How will this problem potentially be overcome? On what machine will this potential solution first be tested? Your answer should include an estimate of how long a fusion power plant could operate based on the world's current reserves of tritium and the reaction that produces tritium from lithium:

Total answers to all the questions should be between 200 and 300 words

Tutorial 5 – Making Fusion Self-Sufficient



What is the Purpose of Tutorial 5?

- To explain the role of the breeder blanket
- To introduce the key equations for tritium breeding

What are the key roles of the breeder blanket?

How much tritium will a fusion power plant need per day?

Which element allows the breeder blanket to breed tritium? What is the equation?

How is ITER implementing breeder blankets?

Additional Notes

Tutorial 5 – Homework: Final Assignment

You are a scientist working at ITER, as part of the breeder blanket team.. One day you receive a letter from a member of the public, Mr Clarkson. Mr Clarkson is unhappy at the amount of money being spent on fusion research when there are plenty of fossil fuels to use. Your task is to write a report to Mr Clarkson, explaining why money is being spent on fusion research. Your report should include:

- Issues with burning fossil fuels
- Problems with completely depending on renewable sources of energy
- A thorough description of how fusion can generate electricity
- The benefits fusion energy can provide
- The successes fusion has had so far
- The role your team has in ensuring fusion becomes a useful form of energy
- A conclusion summarising your main points

However, Mr Clarkson will not take your word for any claims you make. Make sure to back up any claims you make with references.

Here is Mr Clarkson's letter:

To whom it may concern,

I was just watching the news and on came a report about a fancy machine scientists are building in the South of France. You scientists reckon you can build a miniature version of the Sun and make unlimited amounts of energy from it. A Sun, on Earth?! Outrageous! Why should the government spend my tax money on something as ridiculous as this when I can get all the energy I want from coal and petrol? Yes, yes I know all about the air pollution but surely a few more of those windmills and sun panels will do the job. How can carbon dioxide even cause the planet to warm up its just a gas like air? You scientists say your machine is 10 times hotter than the Sun and yet your machine doesn't melt? The Sun doesn't even produce electricity does it so how is building a Sun on Earth going to produce electricity? Its just going to make everything really hot, I thought you scientists didn't want things to get hotter. And where is all this material going to come from to build the Sun. I thought the Sun was a hot ball of gas, where are we going to get that material, mine it from the Sun? This whole idea sounds like its just been thought up in 10 minutes, I bet none of it has even been tested out. How can you sleep knowing you are taking hard working peoples money, why do you deserve it?

J. Clarkson

Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well…	What I could have improved on…
•	•
•	•
•	•

My target for future work is…

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
• • •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

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

What is a reference?

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

Why should I reference?

Referencing is important in your work for the following reasons:

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

When should I use a reference?

You should use a reference when you:

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

How do I reference?

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

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

    a. Websites – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

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

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

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

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

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

Appendix 2 – Using the VLE

VLE username	
VLE password	

Please remember the following key details…

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

What is the VLE?

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

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

How should I use the VLE?

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

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

IMPORTANT: Final assignment

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

Notes

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Key Stage 4 Programme

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