Can we understand the Universe by gluing doughnuts together?

Key Stage 4 Programme

Pupil Name

Handbook Designed by Niccolo' Salvatori

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1			
2			
3			
4			
5			
6 (Feedback)			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Baseline Assignment	
Tutorial 2	Handout	
Tutorial 3	Handout	
Tutorial 4	Handout	
Tutorial 5	Final Assignment	

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after _____on_____	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

The Brilliant Club KS4 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

If marks have been deducted (e.g. late submission, plagiarism) the RIS Teacher 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 *Enter feedback here*	How you could improve in the future *Enter feedback here*
Learning Feedback Comment 2 – *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Learning Feedback Comment 3 – *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Resilience Comment	
How you showed learning resilience during the course *Enter feedback here*	How you could build learning resilience in the future *Enter feedback here*

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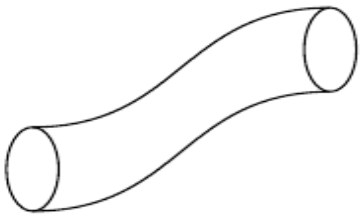
Course Rationale

The mysteries of the Universe, such as its origin, its structure, and its laws have always fascinated humankind, who has tried from unmemorable time to explain it with the use of mathematics. After centuries of discoveries and failures, physicists came up with two great mathematical models (or *Theories*): General Relativity and Quantum Mechanics. The first explains how the big masses in the Universe interact (planets, galaxies, etc.), while the latter deals with the interaction of subatomic particles. Unfortunately, neither of them can be extended to the realm of the other: General Relativity does not make sense when we study the "very small" and Quantum Mechanics does not answer to all the questions for the "very big".
Luckily, there is a theory that seems to make sense in both situations: String Theory. The main feature of this model is the interpretation of subatomic particles as vibrating strings, which describe "tubes" (that is cylinders) when they move in space.



In this course, we will learn about these fascinating theories and the mathematical tools involved. They naturally evolve to the study in Geometry of surfaces with particularly nice features, which we will call "smooth". An example of such surfaces is the "doughnut", which in mathematics is called *torus*. We will define how to "glue" two surfaces together and how to deform them without breaking them. This will give a mathematical representation of the interaction of two particles in String Theory.
Our journey will lead us to the definition and interpretation of one o the most useful and well-studied objects in mathematics: the logarithm. All of this, from a simple string!

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	• 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.	• 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.
Critical Thinking	Research and Evidence	• Use evidence/ calculations to support claims/ assertions/ideas, consistently clearly and convincingly	• Use evidence/ calculations to support claims/assertions/ ideas, mostly clearly and convincingly	• Use evidence/ calculations to support claims/assertions/ ideas, at times clearly and convincingly
Critical Thinking	Developing an Argument	• 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 point of view or position in relation to the title or question is adequately clear • Argument/proof clear and well-developed and position justified	• A point of view or position in relation to the title or question is somewhat clear • Argument/proof clear but not well-developed
Written Communication	Structure and Presentation	• Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment, with clear introduction and conclusion. • All calculations, formulas and methods are clearly structured, clear to follow and correct	• Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment, with adequate introduction and conclusion. • Calculations, formulas and methods are mostly structured, clear to follow and correct	• Ideas are presented in paragraphs and arranged in a structure, with some introductory and conclusive remarks • Calculations, formulas and methods are not always structured, clear to follow and correct.

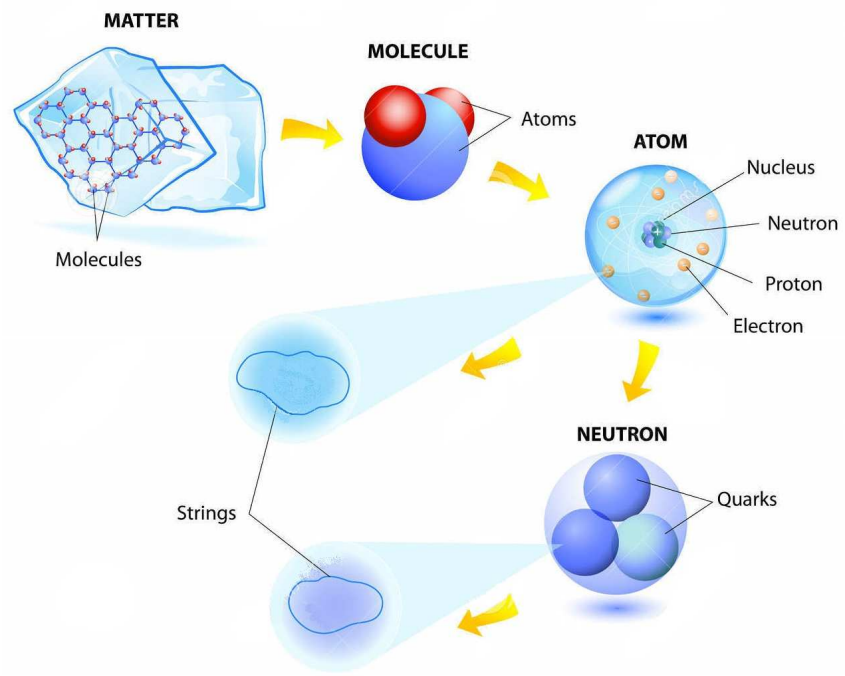
Glossary of Keywords – we will complete them throughout the course

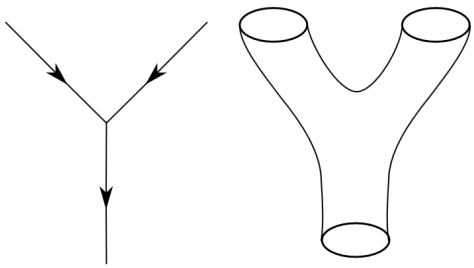
Word	Definition	In a sentence
Atom		
Circle		
Cylinder		
Decomposition		
Deformation		
Disc		
Edge		
Electron		
Euler number		
Function		
General Relativity		
Genus		
Gluing		

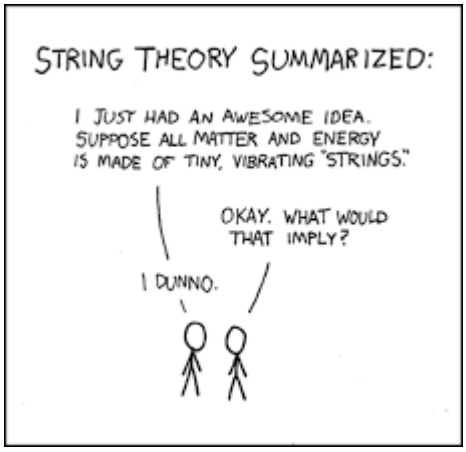
Word	Definition	In a sentence
Interaction		
Logarithm		
Mathematical model		
Matter		
Molecule		
Neutron		
Nucleus		
Pair of Pants		
Polyhedron		
Proton		
Quantum Mechanics		
Quarks		
Sphere		

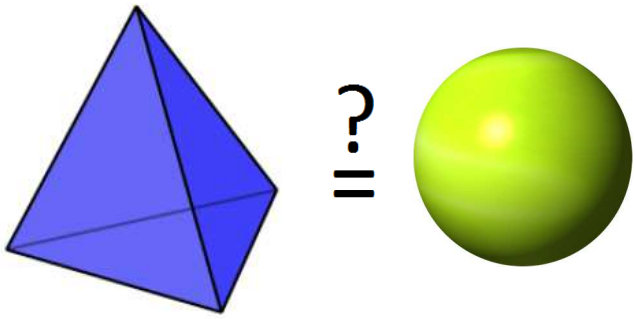
Word	Definition	In a sentence
String Theory		
Tetrahedron		
Torus		
Universe		
Vertex		

Tutorial 1 – A Universe of strings









What is the Purpose of Tutorial 1?

- To become familiar with the key ideas of String Theory
- To understand the difference between a polyhedron and a smooth surface
- To introduce the concept of gluing of surfaces and combination of information

Key Questions:

- What are the smallest constituents of the Universe?
- What are the theories currently adopted by physicists to explain the Universe and matter?
- What does it mean "to glue two surfaces" together and how does that relates to String Theory?

Homework 1:

Baseline assignment at page 12

Notes

Homework 1 – Baseline Test

This assignment consists of a baseline test to check what the first impact with this new topic is. Its purpose is to see what you remembered from the lesson and provides a starting point for our work in the next few weeks.

The mark in this test is not important, but the feedback will be, as it will help you to improve your understanding and your performance in the following weeks, and will help your teacher to get to know you and find the best way to work together to improve your academic skills and your understanding of the subject.

Activity 1

Write a short paragraph on String Theory and its relevance in today's theories of Physics. Try to explain the role of mathematical modelling in physics and why the idea of "gluing" of surfaces is used in String Theory. Although you can use your own words to explain these concept, please try to use the appropriate vocabulary you were given during the lesson.

Activity 2:

- Describe in your own words what a smooth surface is.
- Draw a smooth surface of your choice
- Draw a "non-smooth" surface of your choice and explain why it is not smooth.

Activity 3:

Without using a calculator, do the following calculations and show all of your working:

Work out : (a) $\frac{2}{5}+\frac{3}{8}$ (b) $5\frac{2}{3}-2\frac{3}{4}$ (c) $1-\left(\frac{1}{3}+\frac{1}{6}\right)$

Simplify : (a) $m^2 \times m^4$ (b) $\frac{n^7}{n^4}$ (c) $\frac{x^2 \times x^3}{x^6}$ (d) $(p^5)^3$

Expand and simplify : (a) $3(x-5)+(2x-4)$ (b) $(t+5)(t-7)$

Solve the following equations :

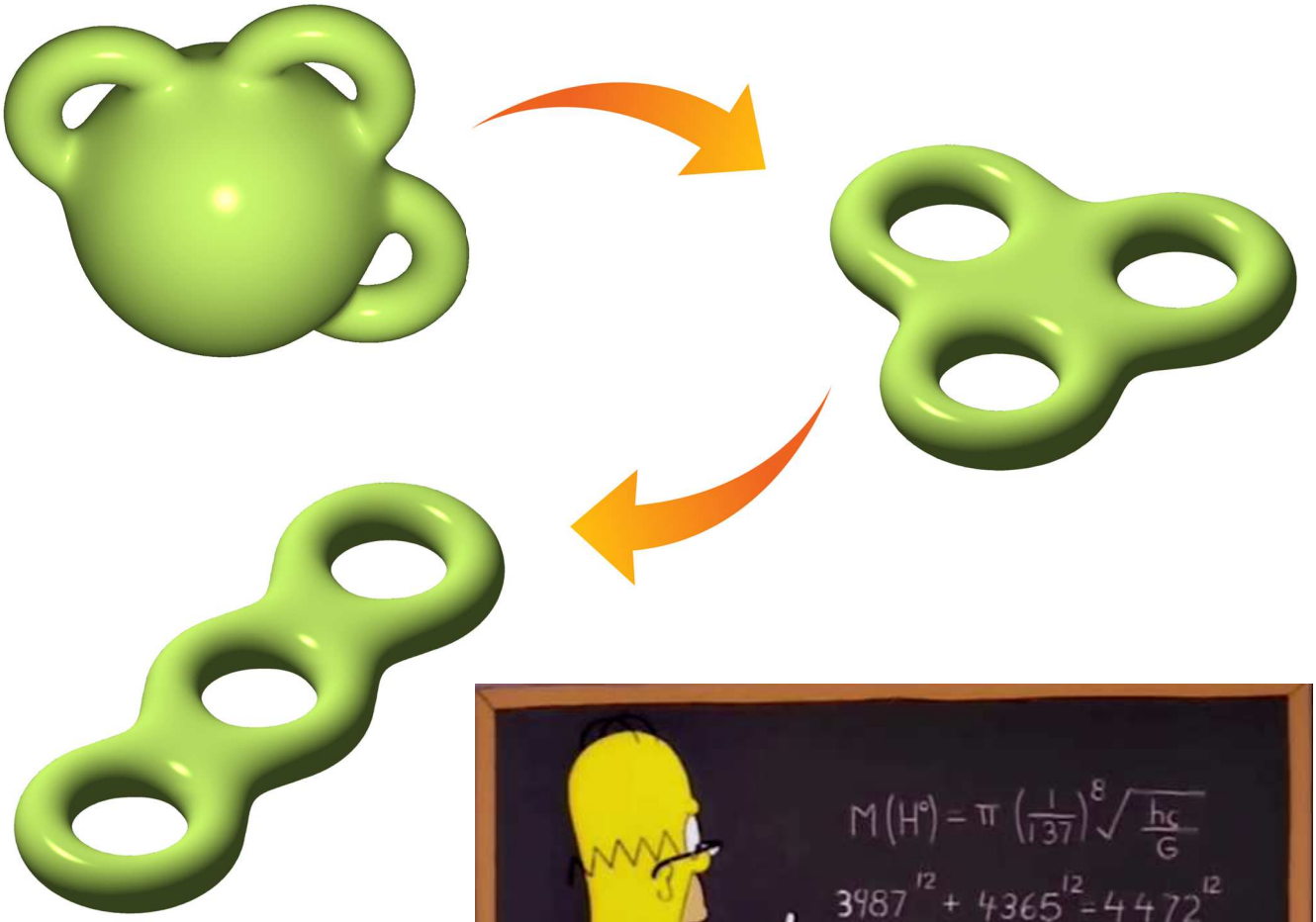
(a) $4(2y-5) = 32$ (b) $5p+7=3(4-p)$ (c) $\frac{x-3}{5}=x-5$

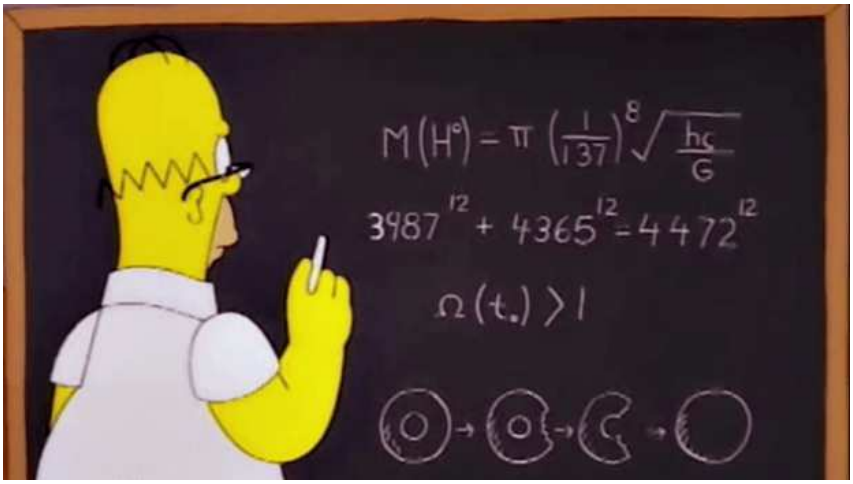
Factorise : (a) $7x+21$ (b) $xy-2x$ (c) $6x^2-18x$

Simplify : (a) $m+m+m$ (b) $n \times n \times n$ (c) $p \times 3q \times -5pq$

Notes

Tutorial 2– Smooth surfaces and deformations





What is the Purpose of Tutorial 2?

- To understand the idea behind a smooth surface
- To understand what a smooth deformation is
- To recognise which surfaces can be smoothly deformed into one another and which not

Key Questions:

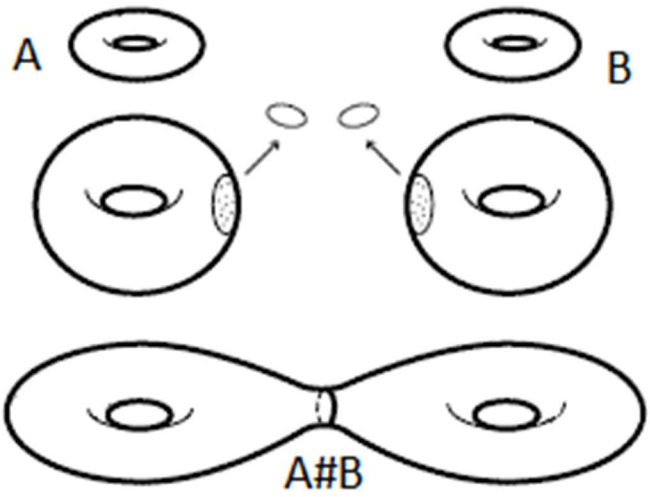
- What is the difference between a surface and a smooth surface?
- Can you provide examples of smooth and "non-smooth" deformations?
- Which features of a surface can be preserved by a smooth deformation?

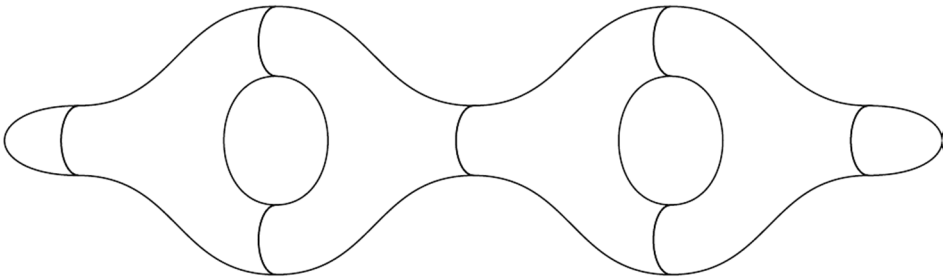
Homework 2:

See today's handout

Notes

Tutorial 3 – Gluing doughnuts





Surface of genus 2

What is the Purpose of Tutorial 3?

- To understand the idea behind the "gluing" of surfaces
- To understand how to create different surfaces by gluing
- To decompose a surface into basic components
- To define a genus and see that it is invariant of the decomposition.

Key Questions:

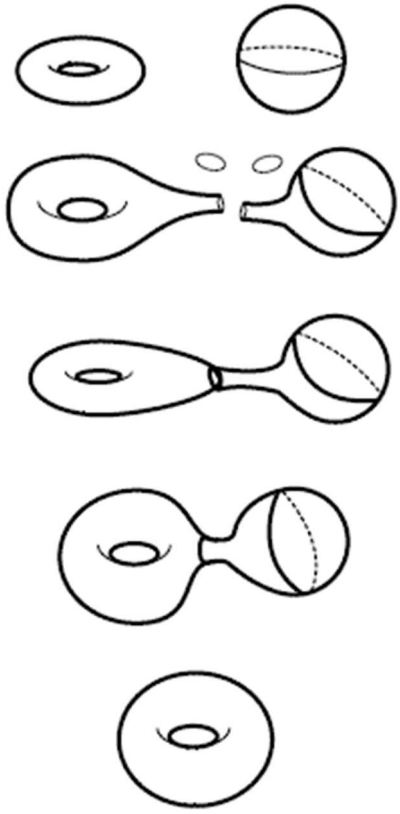
- How do we "glue" two surfaces together?
- What is the genus of a smooth surface?
- In how many "pair of pants" and discs can we decompose a surface of genus 1? And in how many "pair of pants" and discs can we decompose a surface of genus 2?

Homework 3:

See today's handout

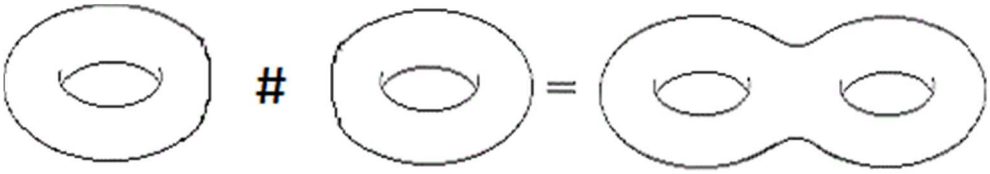
Notes

Tutorial 4 – Combining pieces of information



Leonhard Euler (1707-1783)

$$\chi(A) + \chi(B) = \chi(A\#B)$$



What is the Purpose of Tutorial 4?

- To understand that there are characteristic numbers associated to surfaces, as well as to particles
- To understand how some characteristic numbers combine when gluing two surfaces together
- To introduce the logarithm as a model for the combination of such characteristic numbers

Key Questions:

- What is the Euler number of a surface?
- What happens to the Euler numbers of two surfaces when we glue them together?
- What is a logarithm?

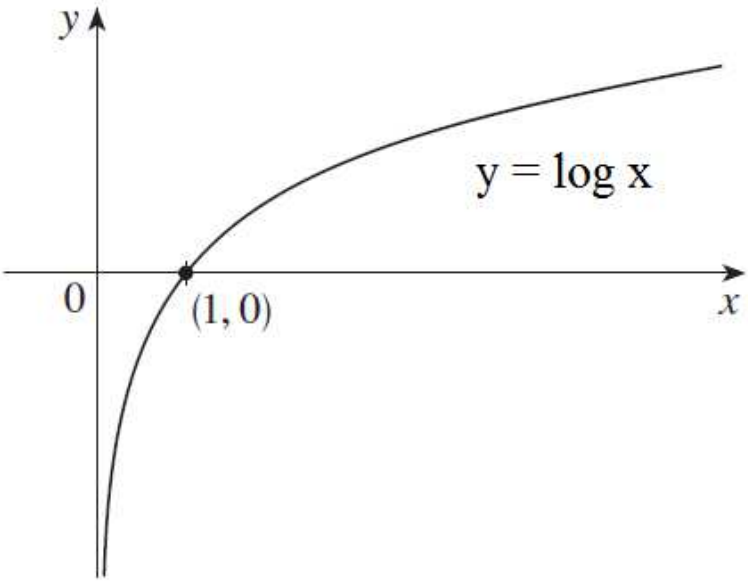
Homework 4:

See today's handout

Notes

Tutorial 5 – The Logarithmic Function

$$\log ab = \log a + \log b$$



What is the Purpose of Tutorial 5?

- To define the logarithm of a number
- To prove the fundamental properties of the logarithm
- To be able to use the properties of the logarithm to perform calculations
- To relate the logarithm with String Theory

Key Questions:

- What is the definition of the logarithm of a number?
- What properties does a logarithm have?

Homework 5:

Final Assignment at page 22

Notes

Homework 5 – Final Assignment

This is your Final Assignment and your chance to show all the new academic skills you have practiced in the past weeks. It will be marked according to the marking scheme of page 6, but your commitment throughout the lessons will be taken into consideration, too.

You will have plenty of time to complete this assignment and you will receive a lot of feedback in the next tutorial, so that you will know how to improve and aim for the top mark.

Activity 1 (25 points):

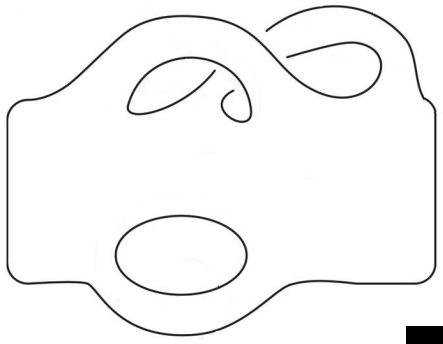
Write a short paragraph (between 1000 and 1200 words) on String Theory and its relevance in today's theories of Physics. As for Activity 1 of the Baseline Assignment (which you can use as a guideline), try to explain the role of mathematical modelling in physics and why the idea of "gluing" of surfaces is used in String Theory. You should use appropriate vocabulary you learned and describe how the concept of logarithm arises. You are encouraged to use online resources that explain String Theory, but keep in mind two warnings: if you use an external resource, you should reference it, and never "copy and paste" its content (this is called *plagiarism*).

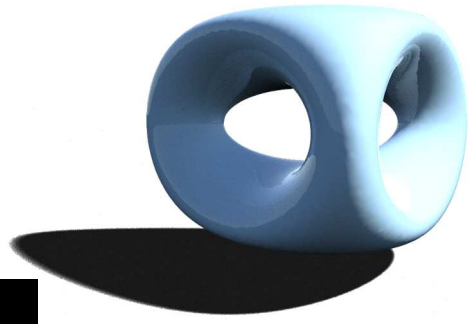
Activity 2 (25 points):

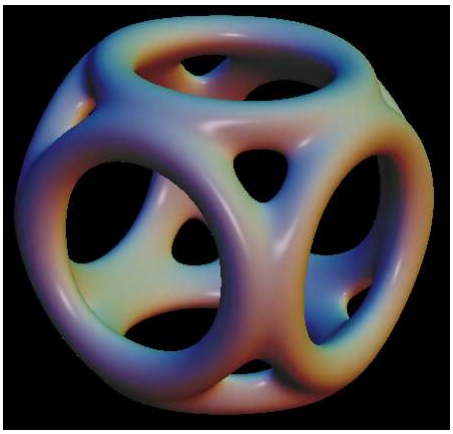
Answer clearly to the following questions. If calculations are involved, show your working.

1. What is the *genus* of a smooth surface? And what is its *Euler number*? Give precise definitions and use the appropriate vocabulary.

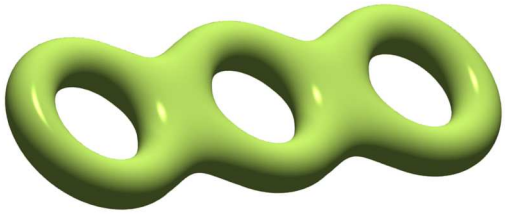
2. Calculate the genus and Euler number of the following smooth surfaces:







3. Decompose the following surface in the smallest number of discs and "pair of pants". How many discs do you have? And how many "pair of pants"?



4. Construct a surface of genus 4 with only discs and pair of pants". Are the genus and the number of "pair of pants" related? If yes, what is their relationship?

5. Simplify: $$\log a^9 + \log a^2 - 5\log a$$

6. Solve:

   a. $\log(x+1) + \log(x-3) = \log x^2$

   b. $\log(11-6x) = 2\log(x-1)$

7. Solve the following A-level problems (from past exams):

   a. Given that

   $$2\log(x-5) - \log(2x-13) = 1,$$

   show that $x^2 - 16x + 64 = 0$.

   Hence, or otherwise, solve $2\log(x-5) - \log(2x-13) = 1$.

   b. Given that $0 < x < 4$ and

   $$\log(4-x) - 2\log x = 1,$$

   find the value of x.

Notes

Notes

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.

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].

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.

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

Notes

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