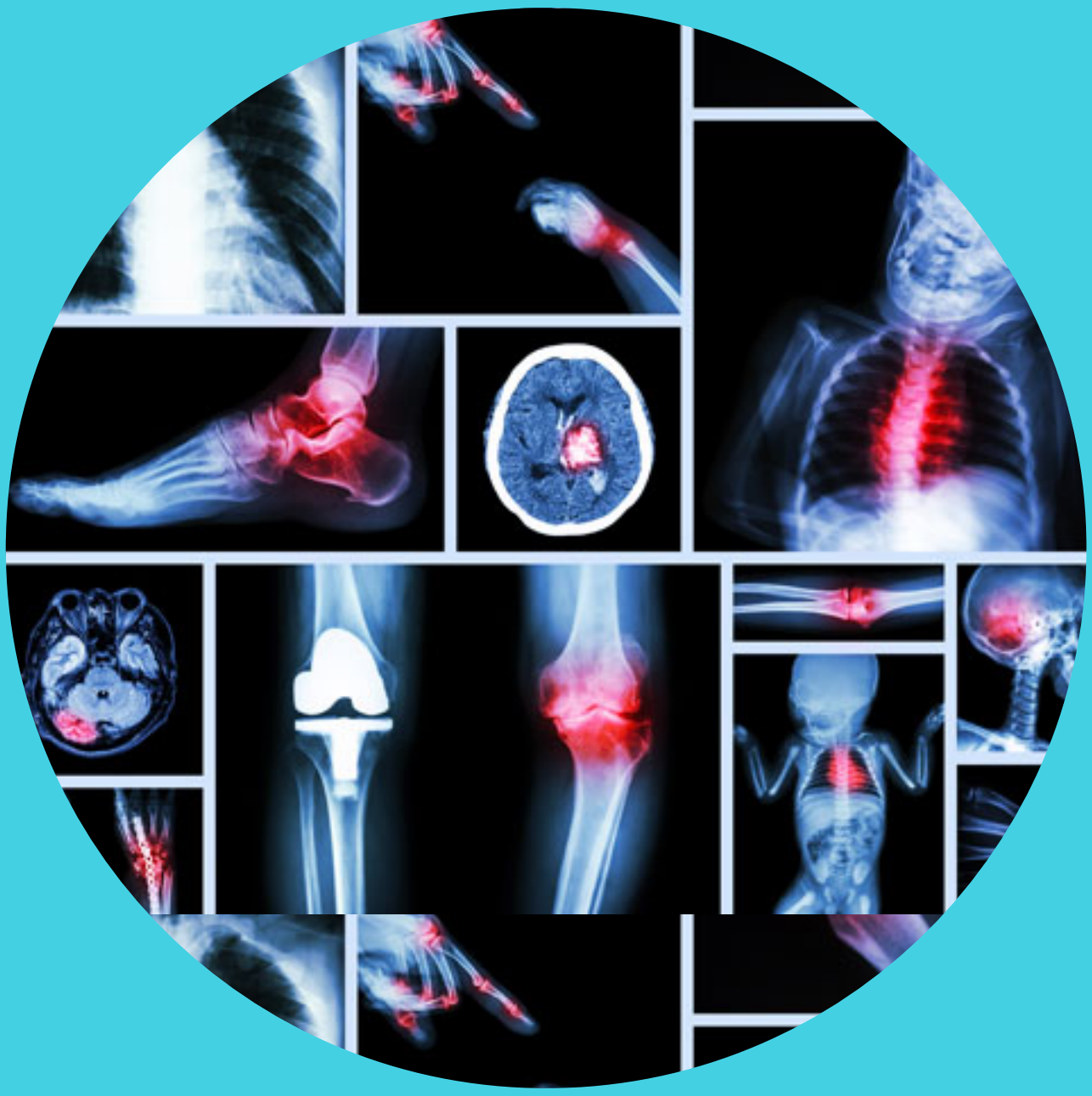

Saving Lives with Maths and Medicine

Key Stage 4 Programme

Pupil Name	
Handbook Designed by	Dr. D. Jethwa

Timetable and Assignment Submission

Timetable – Tutorials

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

Timetable

Tutorials	Description
Tutorial 1	How do Maths and Medicine go together
Tutorial 2	Designing Medical Devices
Tutorial 3	Engineering a Hip Implant
Tutorial 4	Selecting the Right Material for an implant
Tutorial 5	The Final Assignment
Tutorial 6	Feedback

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight 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 A-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. D.Jethwa		
Title of Assignment	Saving Lives with Maths and Medicine		
Name of Pupil			
Name of School	Welling Secondary 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	
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 2	
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 3	
What you did in relation to this Key Learning Priority	How you could improve in the future
Resilience	
How you showed learning resilience during the course	How you could build learning resilience in the future

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Course Rationale

Over the past two decades the emerging field of medical engineering has been at the forefront of tackling problems associated with the human body. Using engineering principles, medical engineers have revolutionised how we treat patients by creating everything from MRI and X-ray scanners to robotic human body parts. With such a diverse field of interest, it's impossible to tell where the future lies for this small field!

Engineering is all about using your hands as well as your mind. Therefore, during this 4-week course we will be exploring the field of medical engineering through a combination of case studies and looking at real life implants. By doing so you'll be able to gain an understanding the thought processes behind the function and design of implants. Finally, you'll summate all of this knowledge by becoming a medical engineer yourself and research your very own implant and give creative ideas on how they can be improved.

Mark Scheme Table

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

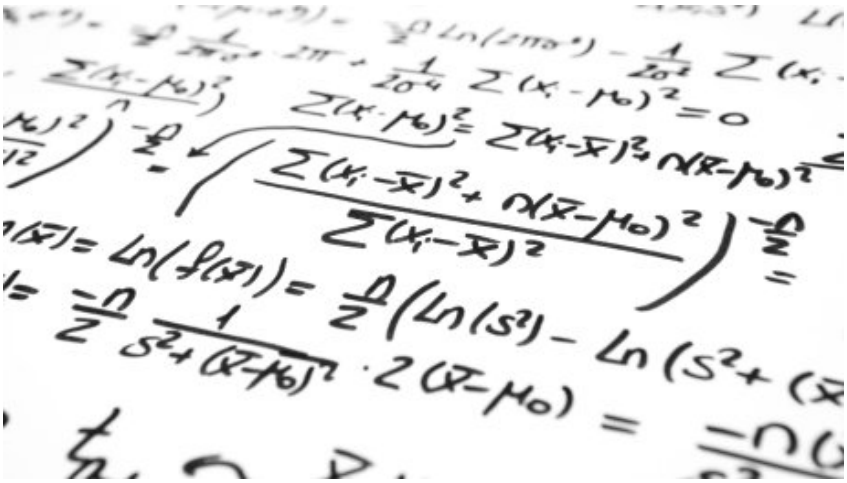
	Critical Evaluation	○ Moved beyond description to an assessment of the value or significance of what is described ○ Evaluative points are consistently explicit/systematic/reasoned/justified ○ Effective critiques on the reliability of sources provided	○ Mostly description but some assessment of the value 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 ○ 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	○ 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, 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	○ 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 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
Medical Engineering	Application of engineering to the human body and range of instruments used within medicine
Implants	An artificial internal body part
Prosthetics	An artificial external body part
Force-Loading	The effect of a force on a component.
Mechanical Failure	The strength at which a material fails with increased force
Computational Simulation	A method of modelling an object without creating it
Joint Reaction Force	The force generated within a joint in response to forces
Abductor Tension	The tension required to align the upper and lower half of the body

Tutorial 1 – How Do Maths And Medicine Go Together?



What is the Purpose of Tutorial 1?

- To understand how medical engineers use maths to solve everyday problems
- To understand the different aspects of medical engineering
- To understand what kinds of devices medical engineers design and create

Activity 1 - What is Medical Engineering?

Circle the words and phrases that are related to medical engineering

Healthcare

Prosthetics

Computational

Problem-Solving

Robotics

Physics

100 year old field

Well-paid

Research

Testing

Clincal

Desk-based

Innovative

Teamwork

Theory based

20 year old field

Use the lines below to write a definition of what medical engineering is

.....

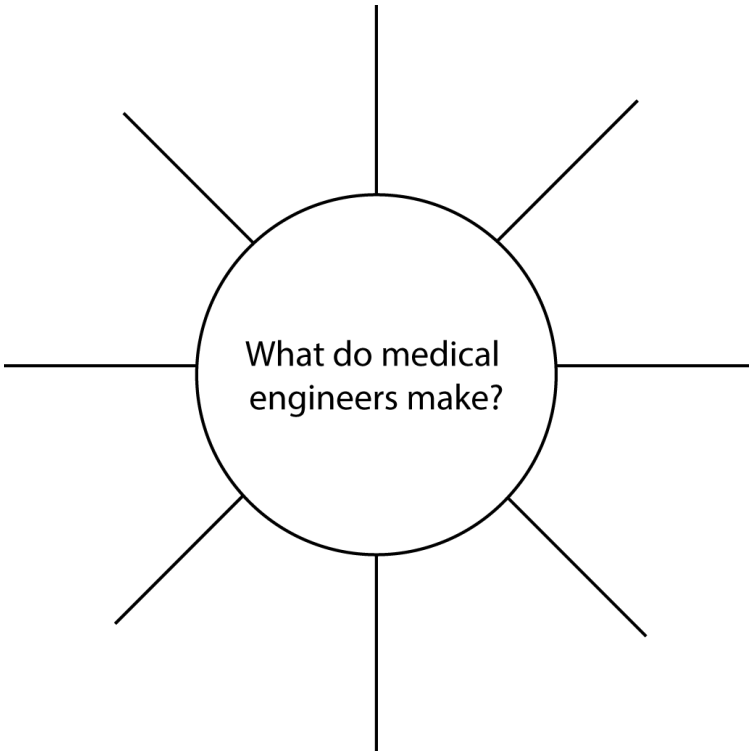
.....

.....

.....

Activity 2 - What do Medical Engineers design and make?

Fill in the spider diagram below about what medical engineers make



Notes

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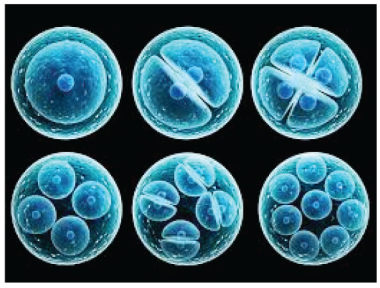
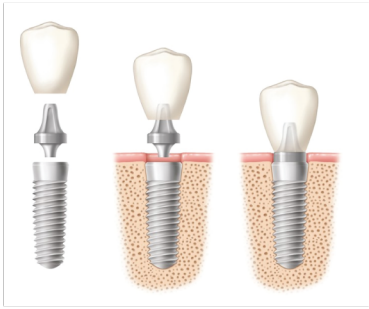
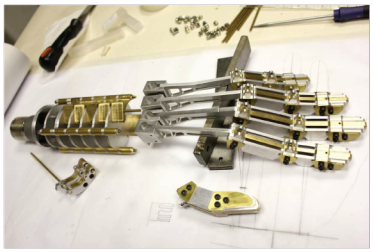
Activity 3 - Match up the medical devices with their function







Hip Implant

Femur

Proshetic Knee

Kinetic hand

Stem-cells

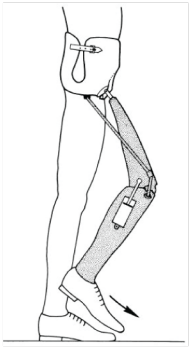
Lower-limb prosthesis

Shank

Crown

Stent

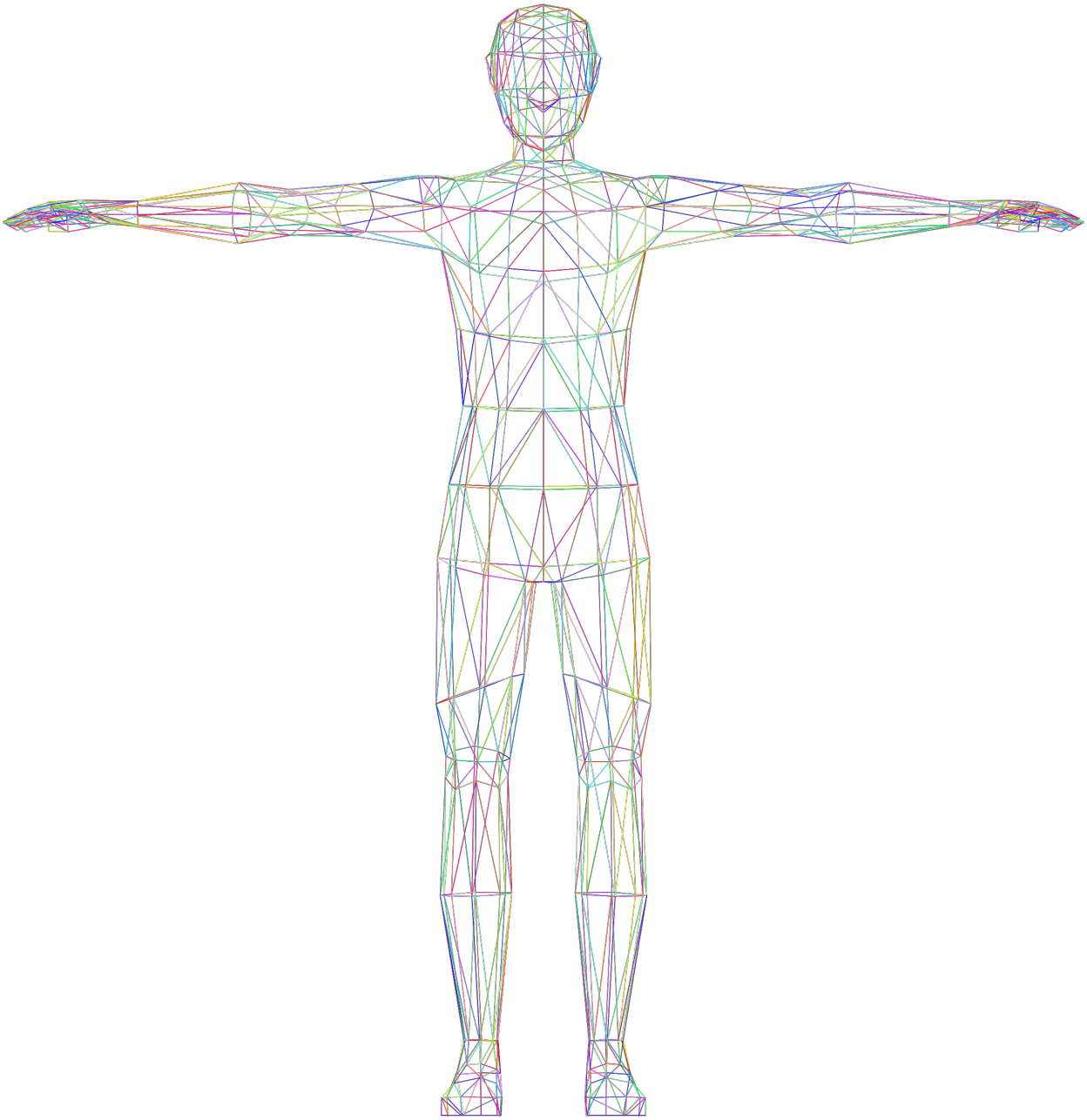
Valve



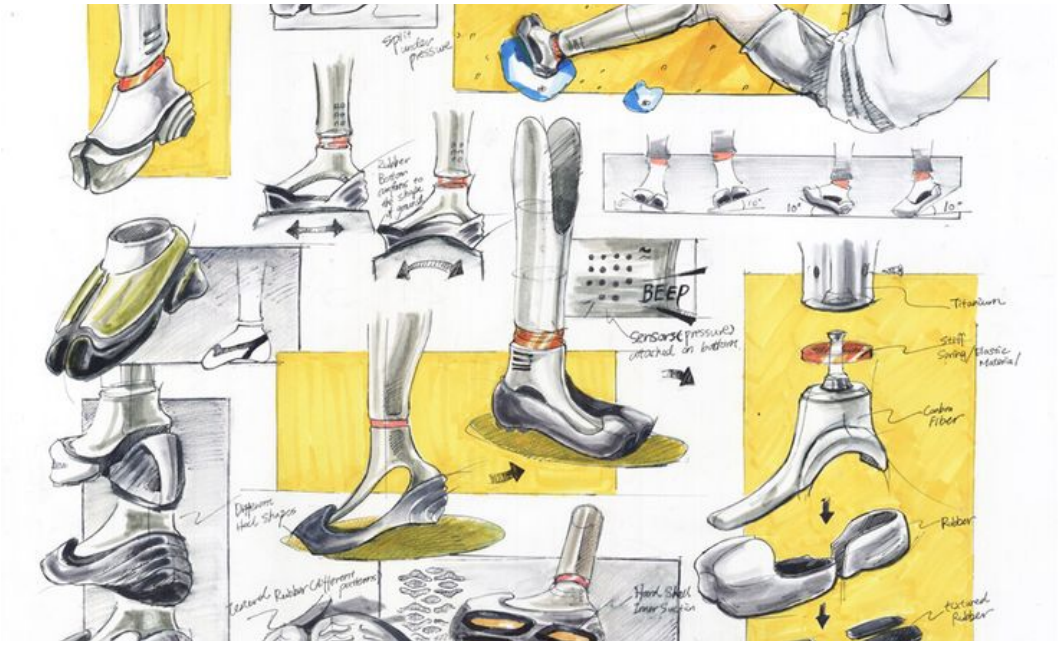
Notes

Homework 1

Below is picture of the human body. By doing research online, label the diagram below with all the places a prosthetic or implant could be placed.



Tutorial 2 – Designing Medical Devices



In this second tutorial we will discuss how medical devices transition from a concept, to ideas to a final product.

Engineering design is an important aspect of an engineer's job. Engineering design is the process of devising a system whereby the end needs of a product are met. In basic science and mathematics, the process is similar to that of 'scientific method' where by a larger project is broken into smaller parts.

What is the Purpose of Tutorial 2?

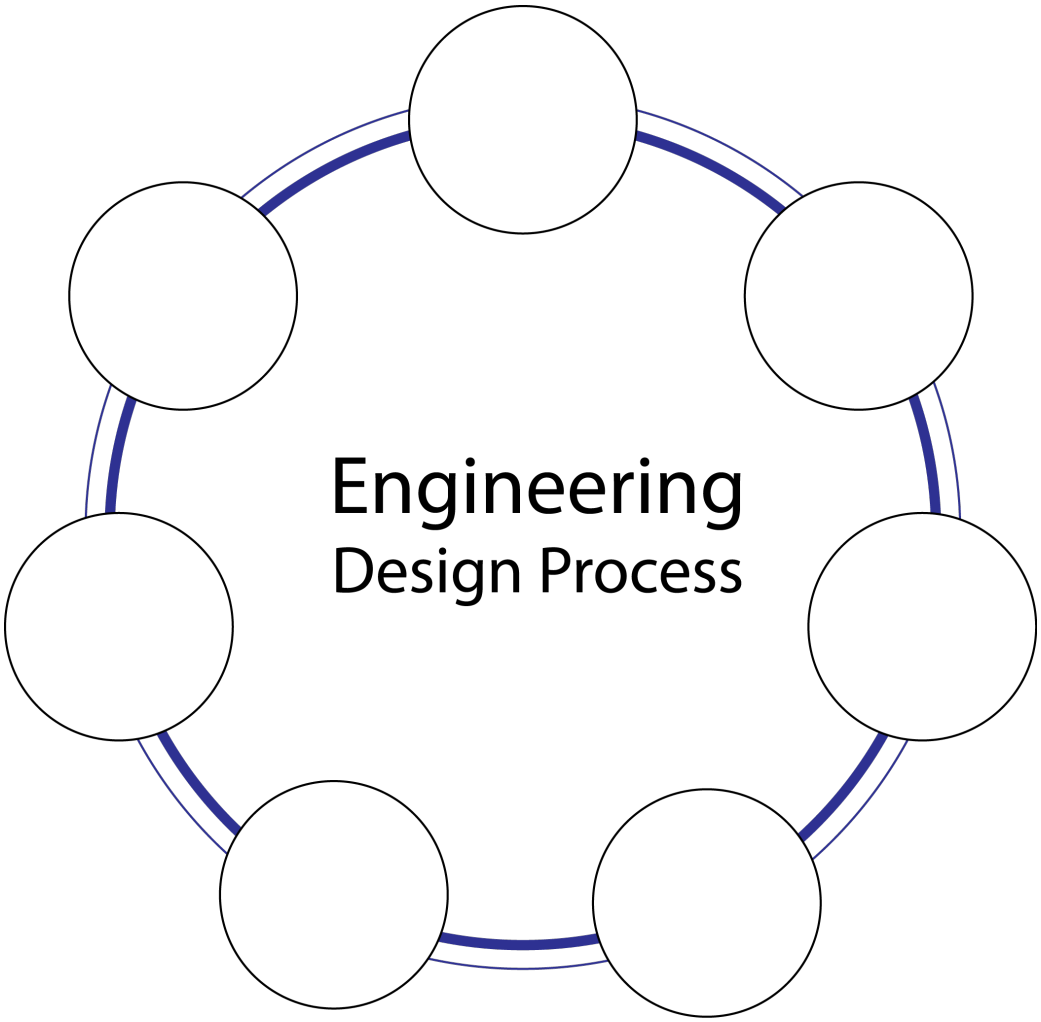
- To understand the process of designing a medical device
- To understand what factors need to be taken into consideration when designing an implant

Activity 1 - How do we design a product?

Before a product can be created, it must be designed to fit its purpose. The engineering design process consists of a number of steps that help engineers come up with a solution to a problem. By using a process such as this, we can use a methodical approach to problem solving.

On the next page you'll see a design circle, which represents the 'engineering process'.

Fill in the design circle below with the step involved in creating a device:



Activity 2 – What factors needs to be taken into consideration when designing a product?

When designing a product, a number of factors must be taken into account. In the next activity we will be looking specifically at a hip implant.

The most common reason behind needing a hip replacement is osteoarthritis in the hip joint. During osteoarthritis, the bones of a joint shear away causing pain during movement. Currently, the only treatment is a surgical procedure whereby the old hipbones are removed and a new implant is inserted.

When designing a hip implant, a number of factors must be taken into consideration. Broadly speaking, factors can be categorised as:

1. **Internal** – Factors related to the design of the implant
2. **External** – Factors related to insertion of implant

Using the table below, separate the factors into internal or external factors and add more to complete the table.

Factors:

Size Cost Material Forces

Skill required for insertion Life Span

Internal Factors	External Factors

Notes

Homework 2

Case study: You are a medical engineer and have been asked to design a knee implant. Make a list of the factors that you must consider when designing an implant explaining the importance of each one. When you've finished your list, define how important you think each factor is*.

* Rate from 1-5 from not very important (1) to very important (5)

Design Factor	Importance	Importance Rating

Tutorial 3 – Engineering a Hip Implant

In the last tutorial we looked at the factors influencing a hip implant. In this tutorial we will continue to study the hip implant and how it has been biomechanically designed to carry out it's function.

(Biomechanics is the study of forces acting on biological systems (i.e, humans, animals, plants, etc.))

What is the Purpose of Tutorial 3?

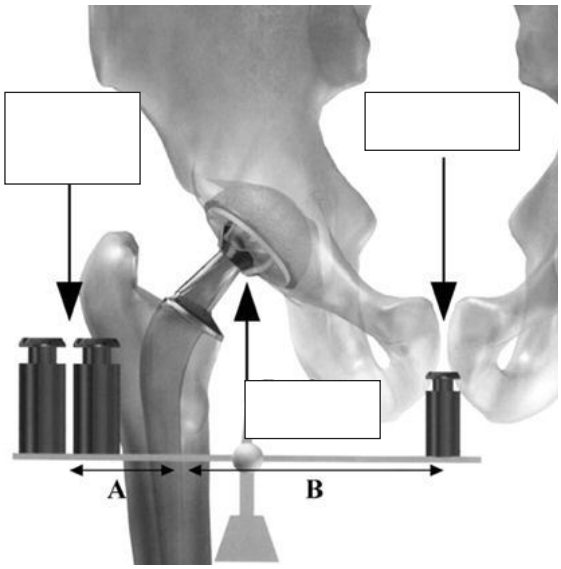
- To understand how different forces affect implants
- To understand how one can test the failure of an implant before creating it

Activity 1 - What are the forces acting on the hip?

Before we can calculate the forces actin upon the hip, we must determine what the force-role of the hip is.

Part A:

On the diagram below, identify where **body weight, abductor tension and hip-force** are placed.



Part B:

What do measurements A and B represent:

A:

B:

Activity 2

Fill in the blanks to the following sentence:

To maintain the forces within the hip, torques are produced by the ..... and is countered by the ..... This can be put into the following equation:

..... x lever arm A = Weight x .....

Based on this equation, calculate the abductor tension for a 65kg woman with a lever arm A length of 5cm and lever arm B of 15cm.

Calculating Joint Reaction Force

Joint reaction force is the force generated within a join in response to forces acting on a joint. Within the hip, this force is needed to balance the moment between body weight and abductor tension. To calculate the joint reaction force you use the following equation:

Joint Reaction Force = (Body Weight + Abductor Force) / Cos 30°

Based on this equation, calculate the joint reaction force for a 65kg woman *(hint: use your workings out from the previous question).*

Notes

Homework 3

Question 1

By researching online, find the top 3 reasons why an individual may need a hip implant. Think about what specific diseases could lead to erosion of the hip.

Disease	Description

Question 2

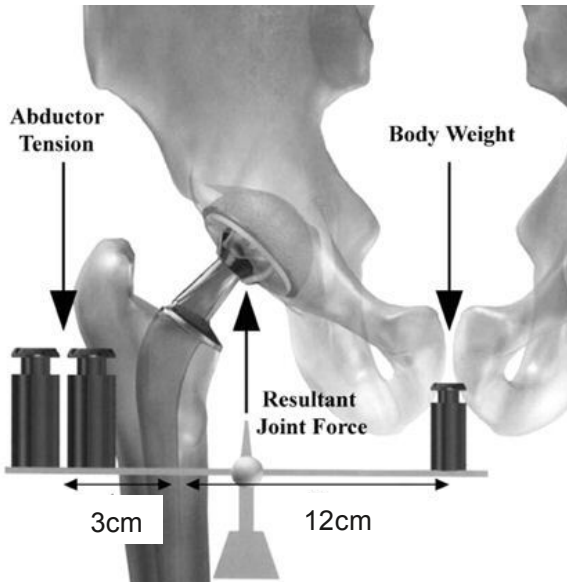
A. Calculate the abductor tension for a 72kg man with a lever arm A length of 6cm and lever arm B of 17cm.

B. Calculate the joint reaction force for the 72kg man.

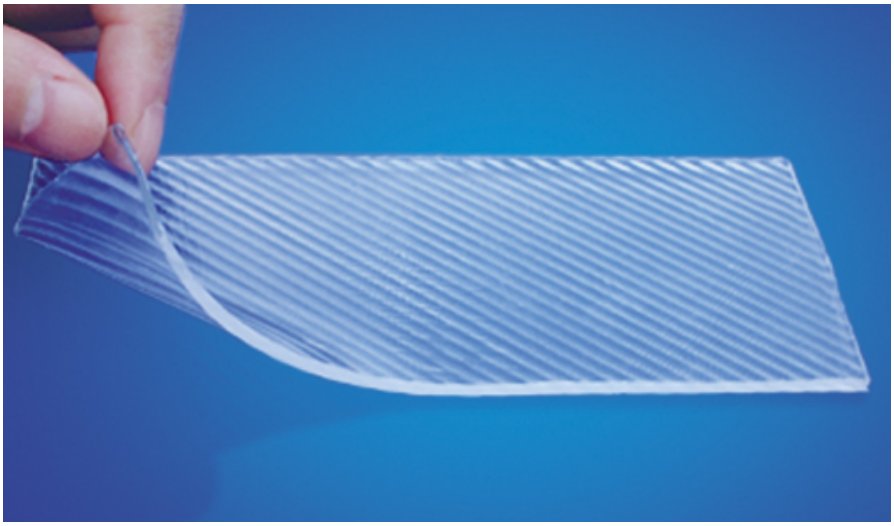
Question 2

A. A child of 12 years (weights 35kg) needs a hip implant. Her x-ray has been shown below.

Calculate the joint reaction force.



Tutorial 4 – Selecting the Right Material For An Implant



What is the Purpose of Tutorial 4?

- To understand what different materials can be used for implants
- To understand the properties of different materials
- To understand how to choose the right material

Activity 1 - What materials can be used in the body?

Selecting the right material for an implant is crucial. Within the body a range of materials can be used. Use the list below to write what material is used where in the body and how strong they are:

1. Silicone

.....

.....

2. Carbon Fibre

.....

.....

3. Titanium

.....

.....

4. Hydroxyapatite

.....

.....

5. Metal Mesh

.....

.....

6. Zirconia

.....

.....

But how do we pick the right material based on strength??

Answer: .....

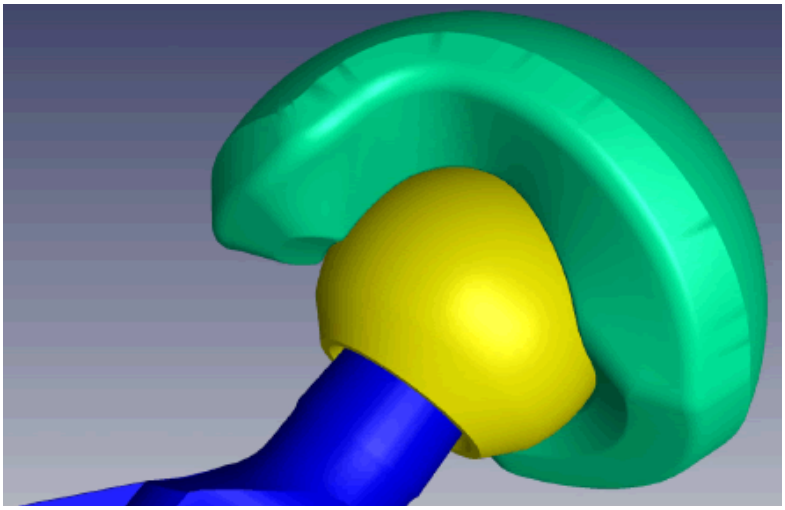
<u>Activity 2</u> – Using the simulator apply different loads to the cases below. Do this is two steps:

Step 1: Identify where the loads are in each case (draw arrows to indicate forces)

Step 2: Describe the deformation under 20N, 50N and 100N cases.

Step 3: What is the best material to use in each case?

1. Hip Implant



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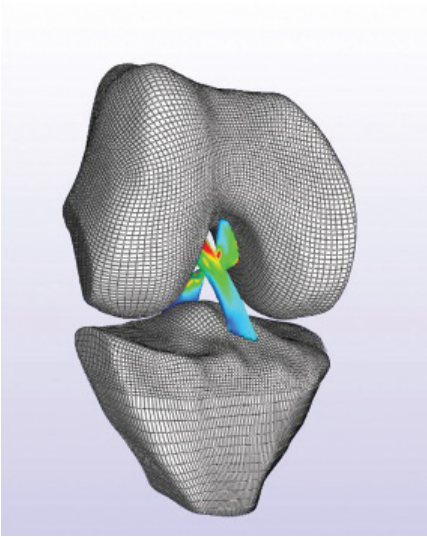
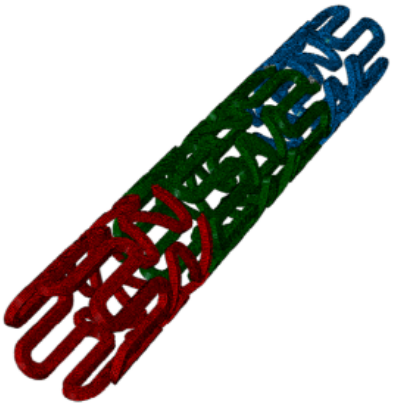
Knee Implant



Heart Stent



Notes

Homework 4

Research why the following materials are suitable for their use in the body.

Material	Where is this material used?	What makes this material suitable?
Silicone		
Hydroxyapatite		
Titanium		
Metal Mesh		

Tutorial 5 – The Final Assignment!

What is the Purpose of Tutorial 5?

- To understand the components of a scientific report
- To explore the biomechanics and engineering of a self selected implant

The Final Assignment

Throughout the past 4 weeks you've learnt the process that goes behind designing a medical implant. Now it's your turn to do so!

Pick one of the following implants and discuss how it is used within the industry.

1. Heart valve

3. Artificial finger joint

4. Knee Implant

Your essay should consists of 4 main areas:

A. Introduction to implant (200 words)

B. How the design on the implant aids its function (300 words)

C. How the implant has been designed to resist forces within the body (200 words + calculations)

D. What material is your chosen implant made from (200 words)

E. Conclusion regarding the future of the implant (100 words)

Please ensure you reference your text and any figures you may wish to include.

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 – How to Reference

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

Notes

Notes

Saving Lives with Maths and Medicine

Key Stage 4 Programme

researchersinschools.org