Simulating A-level Physics

Gold Crest Award

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Contents

Abstract

The issue with existing physics simulations is the lack of focus on required practicals that A-level physics students are required to learn. In this project, Visual Basic was used to create eight new simulations that aim to help those individuals to self-teach and revise from, because, as research suggests, students have a tendency to prefer simulations over practical physics and find them to be more accurate and less time consuming. An eye-catching user interface was consistent throughout which was echoed in user feedback. Comments also indicated that students were very likely to use the program in future giving an average rating of 4.67 out of 5 stars for their overall experience when using the program, consequently, I conclude that the 'Physics Simulations' program will be beneficial for most A-level physics students looking for a useful and engaging way to learn.

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Aims and Objectives

The aim of this project is to build a program that will give Physics students a better understanding of practicals without needs for the physical equipment. The result of this project could be used in a classroom setting, alongside physical equipment, or externally, for the students to look back at the experiment setups and interact with them to make more sense of them, if necessary.

I will have achieved my aims if…

- The Program accurately interprets the real practicals in a way that is visually and mathematically no less accurate that in were to be carried out with the physical equipment.
- The program explains certain steps of the program so the students can grasp why they are inputting specific values and be explained to what the program is doing behind the scenes, mathematically, in a way that will be just as useful for the student to learn the process.
- The program is quicker to carry out than the physical counterpart, therefore making it more time efficient.

Objectives

- Research existing practicals to determine the issues with the existing solutions to then solve with my new program.
- Research a more in-depth knowledge of some of the practicals in order to be able to fully understand the science behind certain equations to then help the students, using the program understand more, the practical that they are doing.
- Find out what students find to be the most beneficial part of using simulations is and what improvements they would make to currently used simulations, so that I can focus my time on ensuring the students' needs and requirements are maintained if the transition was to be made from currently used simulations to the program of simulations developed as a part of this project and incorporating more thorough explanations for better grasp of the information, from the students.

Introduction

The inspiration behind this project is to create a solution to the challenges within, the process of completing, A-level Physics Practicals, of which, I found to be the issue to be the spotting of incorrect results; time in which each measurement takes to obtain and the overall accessibility of them. This stems partially from a year of periodic and unplanned lockdowns because of the 'COVID-19' Pandemic (2020/2021), during which practicals from home were deemed impossible to carry out. This was due to no equipment to access physically, and the simulations provided online were not satisfactory for learning the practical and understanding the physics behind them therefore, I aim to create a program, using 'Visual Basic' as a programing language, that will allow students to carry out practicals via simulations in a program, in a much shorter time frame, whilst being able to learn the physical process, with very clear and accurate results, that, if possible, you could conclude alongside a physical representation of the program.

Research into Existing Simulations

There are many different existing simulations that currently exist yet there are none that are both achieved to a high standard and have the main target audience of 'A-level Physics Students'. I aim to be the first here as, I have noticed that there is lack of simulations that reflect A-level required practicals and many don't show/help with using equations that relate to the simulations which I aim to do.

Visual Basic Research

Mathematical Functions:

I have needed to research many different mathematical terms to be able to use when using physics equations within the background of the simulations.

The first of these functions is to be able to square root a number. I found the help in the Microsoft website and will be able to use it in several simulations in, for example, the re-arrangement of 'SUVAT' equations or 'Simple Harmonic Motion' equations. ***[1]***

I will also probably need to change the location of a 'picture box' within a form design if I wish to have animations within my form which I think is a given for this project. I managed to figure this out, again, from within the Microsoft website and found the 'Point Structure' which allows me to allocate a 'picture box' to a specific co-ordinate from within the form. ***[2]***

Another mathematical function that I have researched for my program is a way to use 'sin' and 'cos' within my code which are the fundamental trigonometric functions that are used when solving trigonometry problems. I may need these for specific equations such as in, 'Simple Harmonic Motion' equations or methods to calculate 'Work Done' using force. ***[3] [4]***

A 'Round' functions will also be necessary due to the fact that, during calculations, if I wish to display an accurate result for a value, I need a degree of accuracy that is to an appropriate level of significant figures. For example, the number of significant figures in a 'Projectile Motion' question should be answered to 3 significant figures because '9.81' is used for the value of 'g'. I also found this result from the Microsoft website where I was able to successfully investigate how to round a number to a specified number of decimal places/significant figures, so that also, the labels and textboxes in the final program that will display number answers are big enough to hold values. ***[5]***

Exception Handling will be required in the final design of my program to prevent the program crashing from a user input or invalid calculation. This will be in the form of a 'Try-Catch Statement' as I have researched. The specific purpose of this statement in 'Visual Basic' is to first run the code within and if there are no errors produced then the program will continue to run yet if there are errors caught, then the code will not be acted upon, and the user should be displayed with an appropriate error message that I will code into the program using a 'Message Box'. ***[6]***

Finally, to this point, the last part to research has been how to rotate a 'picture box' in 'Visual Studio' using 'Visual Basic'. If I wish to animate a rotating system such as when demonstrating moments, specifically a 'Couple' in rotation, I will need to rotate an image deeming rotating a 'Picture Box' necessary. I researched this using the Microsoft website and was able to find a method of specifically rotating picture boxes in a 'Panel' to a user defined degree in visual basic. ***[7]***

A-level Physics Research

A-level physics students are required to learn 12 practicals under the 'AQA' exam board of which I will attempt to emulate some of. These practicals cover a range of different topics in physics and theories meaning they will also require different visual representations.

Stationary Waves – This required practical investigates the effect on wire with many variables using the 'Harmonic equation'. It is also a very visual practical so could be a good addition to the program as a potential for a simulation.

Diffraction Grating – This practical uses the 'Diffraction Grating' equation and although there are many visual elements to the practical in person, as a simulation the display would be stationary dots so may not be a priority for the program.

Determination of 'g' by freefall – This practical is very simple and requires a lot of physical student interaction yet the result, if carried out perfectly, should be the same every time, so, if converted into a simulation, the display wouldn't change.

Young's Modulus – This practical could act as a good simulation and would be useful for students to compare their physical answers to what the theoretical result should be, so could be a good addition to the program.

Resistivity of a wire – This required practical uses the 'resistivity of a wire' equation and could be a great addition to the program, however, other simulation websites have already made this simulation with multiple different interpretations of the practical, therefore I wouldn't deem this practical as important to include to the program.

emf and Internal Resistance – This required practical uses circuits and is very visual. It also uses the emf equation ($\varepsilon = I(R + r)$) which can be used to make a simulation, yet I don't believe that it will be beneficial for an A-level student to use

Simple Harmonic Motion – This practical uses the equation for a 'Mass-spring System' and a 'Simple Pendulum' and would be great simulation because it is very visual and could use animations within the design to enhance the experience for the student. This could also be very useful for the student because the equations can be rearranged in many different ways which would be much quicker using the simulation to calculate.

Boyle's and Charles's Law – This practical uses equations which the students are required to learn and are not given in the exam so a simulation could be beneficial; in that regard, however, the practical isn't very visually appealing and so wouldn't work as a part of the program.

Charge and Discharge of Capacitors – This practical required constant focus from the student whilst taking readings at specific times before using the 'Discharge' and 'Charge' equations for a capacitor. This focus wouldn't be needed though if there was a simulation to take over that element of the practical for the student. Therefore, a simulation for this practical could be very helpful.

Flux Density of a Wire – This practical uses the 'Force on a Wire' equation which is a very simple equation and the movement on the mass balance is visually negligible so, wouldn't be a visually appealing simulation to include in the program.

Magnetic Flux Linkage with Varying Angles – When this practical is drawn out in diagrams it is displayed in 2D and doesn't look very visually appealing and the equation used for this practical is complex so it would most likely not be an enjoyable simulation to use which is one of the goals in this project.

Inverse Square Law of Gamma Radiation – Again, this practical isn't very visual and so, as a simulation, it wouldn't fit this program, also this simulation has already been attempted, and in every example the display is very bland and doesn't appeal to an A-level Physics student.

Survey

The final part of the research is the survey. The survey aims to gather the opinions of all students on their opinions of simulations in general, compared to the use of practical equipment in class.

Survey

I have used ‘Microsoft Forms’ to create a survey containing 10 questions for A-level students to answer so I can understand what student’s think of simulations compared to practical physics and the benefits they see of both.

Simulating A-Level Physics Practicals (Gold Crest Award Project)

The following 10 questions are about the use of Simulations as opposed to Practical Physics. This should not take you any more than 5 minutes to answer complete so please try to answer all of the questions honestly. If there a ny written answers that you are unsure of how to answer just write ***'IDK'*** and move on to the next question.

...

1. To what extent do you agree with the following statement? *

"Practical Physics always wins over a Computer Simulation alternative, of a Practical"

- Strongly Disagree
- Disagree
- Disagree Slightly
- Neutral
- Agree Slightly
- Agree
- Strongly Agree

The purpose of Question 1, is to understand a student’s general opinion of simulations, as opposed to conducting an experiment practically. The expected outcome is to be varied in response as I think most students would like a balance of both options, as opposed to a preferable method.

Question 2, has been written to gather an overview of student’s thoughts regarding the time efficiency of carrying out an experiment physically in comparison to a simulation. I assume most taking the survey will strongly disagree with this statement.

2. To what extent do you agree with the following statement? *

"Practical Physics takes less time than using a Simulation."

- Strongly Disagree
- Disagree
- Disagree Slightly
- Neutral
- Agree Slightly
- Agree
- Strongly Agree

3. To what extent do you agree with the following statement? *

"Practical Physics helps teach a theory more than a Simulation does"

- Strongly Disagree
- Disagree
- Disagree Slightly
- Neutral
- Agree Slightly
- Agree
- Strongly Agree

This question is to understand how beneficial student’s find simulations when wanting to learn a physics theory as opposed to practical physics. I presume most students will respond between agree and strongly agree because current simulations don’t tend to focus on the physics behind the simulations.

Question 3’s main objective is to grasp a student’s view on the user interface of a simulation by asking them of their opinion on how easy simulations are to navigate. In general, I expect students to agree that simulations are easy to use and navigate as I believe they are and that is one of the main benefits to a good simulation.

4. To what extent do you agree with the following statement? *

"I think simulations are easy to use and navigate."

- Strongly Disagree
- Disagree
- Disagree Slightly
- Neutral
- Agree Slightly
- Agree
- Strongly Agree

Survey

Question 5 has been made to collect attitudes towards whether simulations could be improved or not. This is the main reason I am designing and creating the simulation program so I believe that no students will disagree with this statement.

5. To what extent do you agree with the following statement? *
"I think there are improvements that could be made to existing Simulations for the benefit of students."

- Strongly Disagree
- Disagree
- Disagree Slightly
- Neutral
- Agree Slightly
- Agree
- Strongly Agree

6. If you selected 'Neutral' to 'Strongly Disagree' for the above statement *[Q5]*, What aspects of Simulations do you tend to prefer?

Enter your answer

If students think that no improvements could be made to simulations then I have asked them to give a reason for their decision here, so that I can make sure to maintain the best of current simulations.

This question has been made to understand if students agree that practicals should always be paired with a simulation. I expect results to be varied here because the question is based off of personal opinion, yet I think the results will lean slightly to the 'More common to use a simulation' because if perfected I think simulations are a good resource.

7. How often would you say is preferable for the use of Simulations? *

- Always (Every practical I do)
- Very Often (Rare to not use a simulation)
- Often (Common to use a simulation)
- Sometimes (Not common to use a simulation)
- Rarely (Rare to use a simulation)
- Never (Never use a simulation)

8. As a continuation to the above question *[Q7]*, Why do you think this? *

Enter your answer

The reasoning behind this question is to understand the thought process behind the option they chose in the previous question. I want to know this to evaluate not only students' general opinions of simulations and their using with physical practicals, but also what they first think of when they are asked this question, whether it is positive or not.

The purpose of question 9 is to ask the students direct closed questions to receive direct answers. I expect most students to check the first 4 options and doubt any will check the last because I think simulations are very commonly liked. I also expect the most common option to be the third.

9. Please select any of the following statements that apply to you:

- [ ] I find using simulations a useful revision source.
- [ ] I think simulations could replace the use and need for practical equipment in lessons.
- [ ] Simulations are a good alternative during a pandemic.
- [ ] I think simulations are easily accessible.
- [ ] I do not like simulations

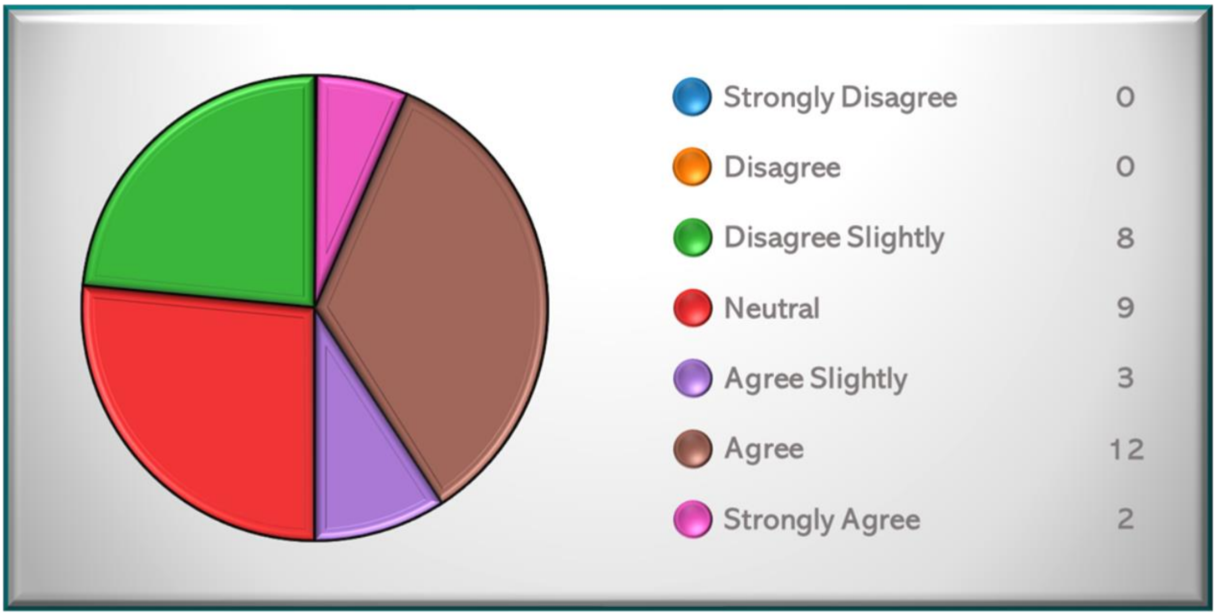
10. If there are any aspects of simulations that you think would benefit you that do not already exist, or have any further comments on the use of Simulations as opposed to Practical Physics, please state them here...

Enter your answer

The purpose of question 10 is to allow the user to be able to make any further comments on the use of simulations in physics and mention any other improvements that they haven't had the ability to with the other questions.

Question 1:

"Practical Physics always wins over a Computer Simulation alternative, of a Practical"



24% of students think that computer simulations are better than practical physics

Half of the students prefer practical physics

Overall, the students tend to prefer practical physics

This could be due to a lack of information provided with most Physics simulations

12/34 Agree

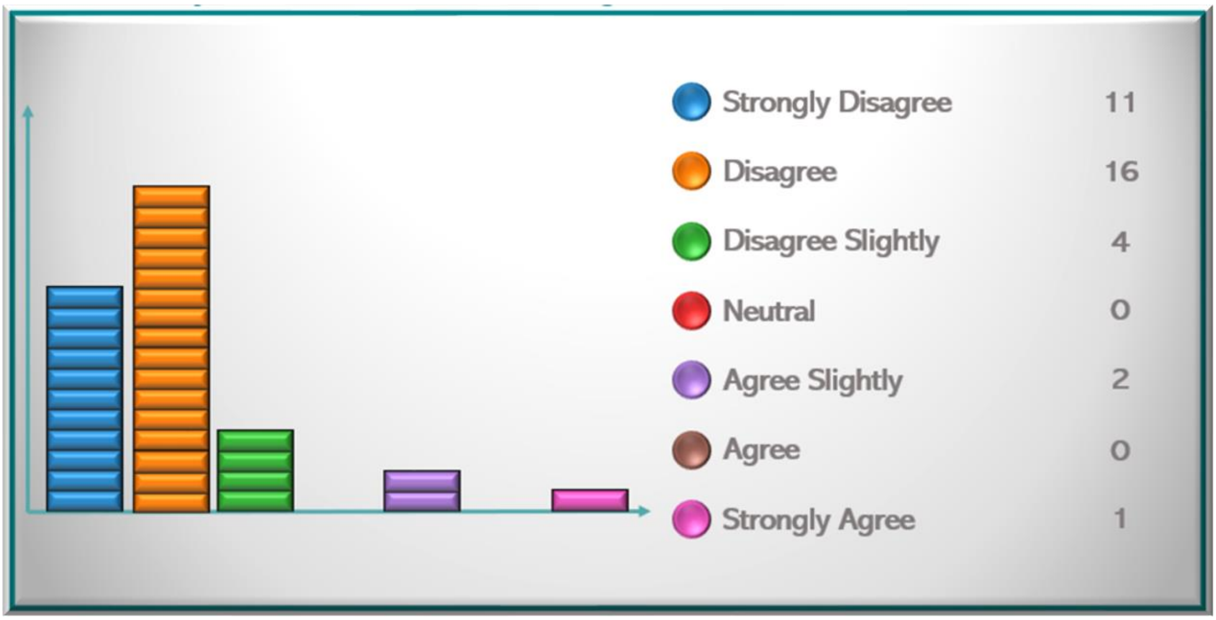
None of the students 'Disagree' or 'Strongly Disagree'

This proves that, in general, simulations need to be improved

- Based off these results it is clear that there is a need for an improvement in existing simulations, so I aim to change these opinions.
- No students like simulations enough to 'Disagree' or 'Strongly Disagree'.

Question 2:

"Practical Physics takes less time than using a Simulation"



79% said they either 'Disagree' or 'Strongly Disagree'

There was **one outlier** in the results

No-one was 'Neutral'

This was the one student who selected 'Strongly Agree'

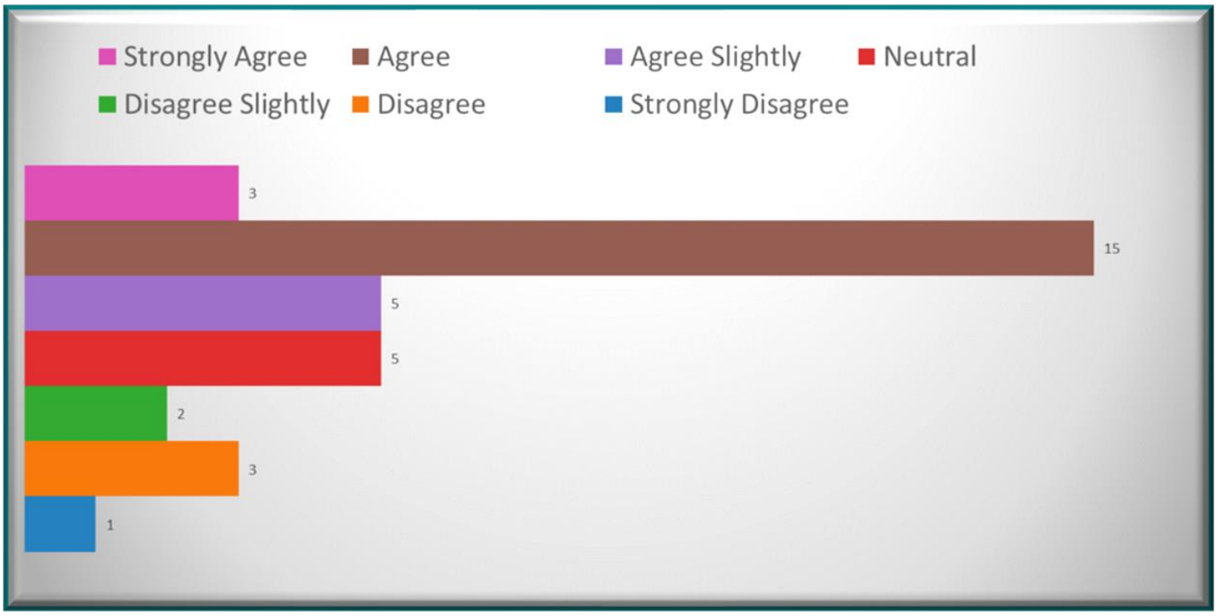
Only **3/34** students said they think **Simulations** are slower than Practical Physics

Overall, students think that Simulations are much quicker than Practical Physics

- These results present that, students, overall, believe simulations take less time than practical physics. This is something that I will need to incorporate and keep within the design process of my program.

Question 3:

“Practical Physics helps teach a theory more than a Simulation does”



82% didn’t ‘Disagree’ in any way

Every opinion was chosen at least once

Most students either selected ‘**Agree**’ or ‘**Strongly Agree**’

Overall, **students** think that ‘practical physics’ is more helpful than simulations to teach a theory

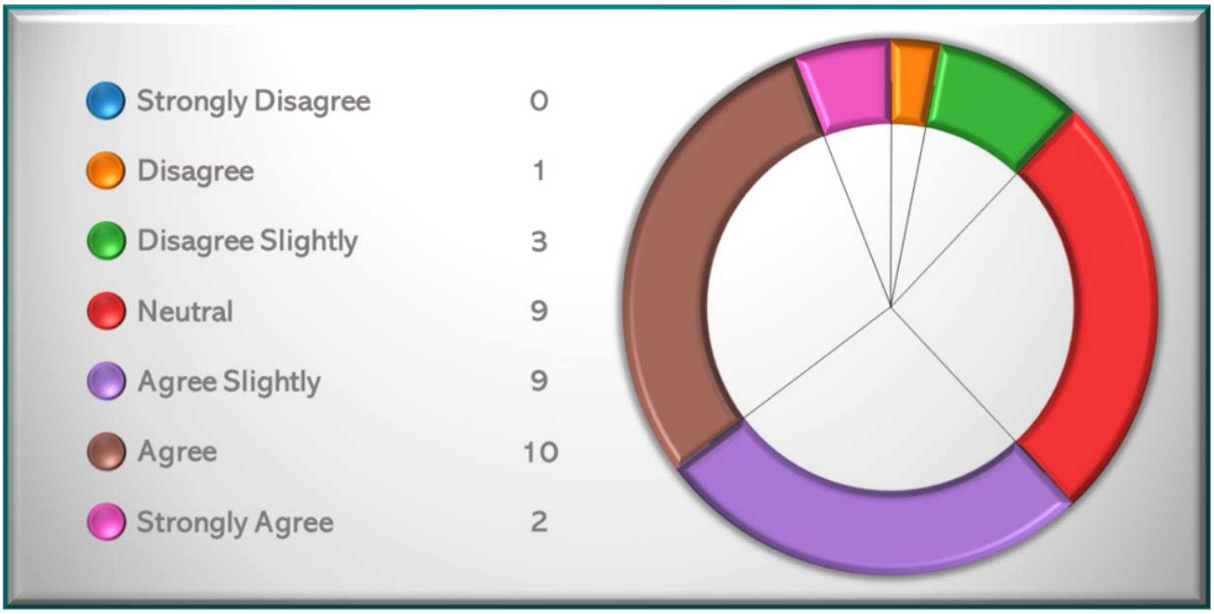
Only 1 student selected ‘Strongly Disagree’

Only **3/34** students said they ‘Disagree’

- The results here show that generally, practical physics its more helpful in teaching a theory than simulations are meaning my simulations will need to be informative enough to keep up with practical physics.

Question 4:

"I think simulations are easy to use and navigate."



No-one 'Strongly Disagreed'

62% of students think that simulations are easy to use and navigate.

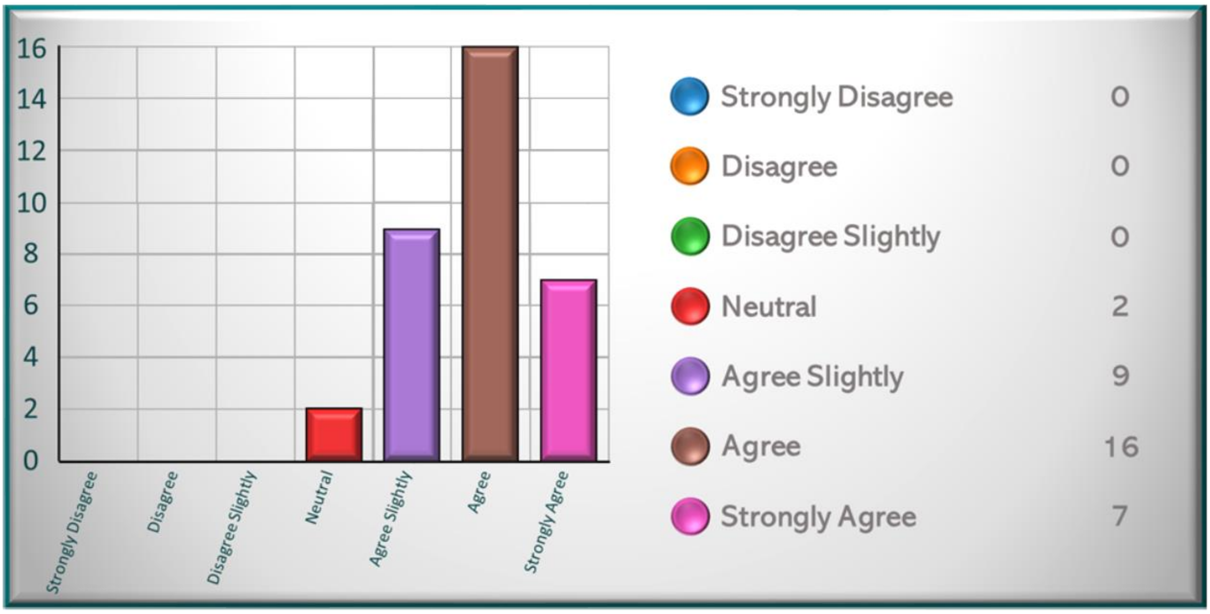
21/34 selected either 'Agree Slightly', 'Agree' or 'Strongly Agree'

Overall, students agreed that simulations are easy to use and navigate

- On average, students are of the opinion that simulations are 'easy to use and navigate' which I will need to make sure to continue in the design and making of the simulations in this project.

Question 5:

"I think there are improvements that could be made to existing Simulations for the benefit of students."



Only 6% of students selected 'Neutral'

No student **disagreed** with the statement

32/34 agreed

Overall, students agreed that there are improvements that could be made to existing Simulations for the benefit of students

7 students selected 'Strongly Agree'

- It is clear to see that, from the results of this question, students believe there are improvements that could be made to existing simulations for the benefit of students. This shows that there is a purpose to this project and there are improvements to be made which I found to be the case during research.
- No students were of the view that simulations didn't have improvements that could be made.

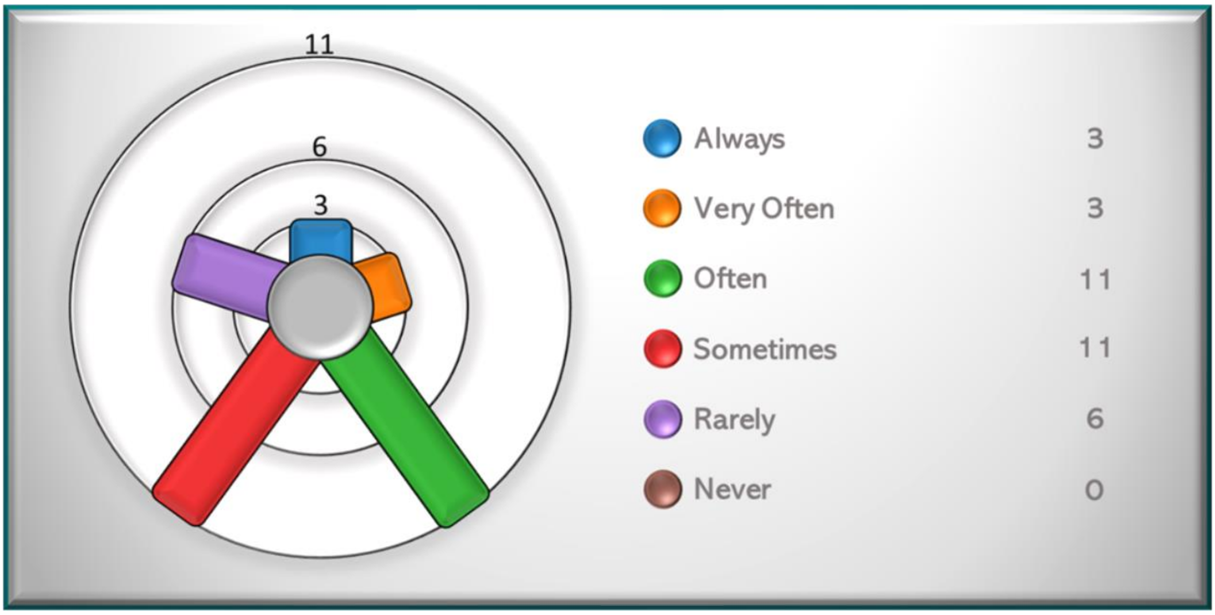
Question 6:

If you selected 'Neutral' to 'Strongly Disagree' for the above statement *[Q5]*, What aspects of Simulations do you tend to prefer?

For this question overall, there was not much feedback provided because almost all the students who answered the survey didn't fall into the category of selecting 'Neutral' to 'Strongly Disagree' for question 5. The one student that did fit the brief to answer the question commented with 'easy to understand UI'. This means that the main element of the program that needs to be maintained after the inclusion of simulations is to make certain that the user interface is clear and easy to use/understand so, navigation must be simple throughout the program therefore a 'Home Page' is necessary.

Question 7:

How often would you say is preferable for the use of Simulations?



50% of students think simulations should be used either 'Often', 'Very Often' or 'Always'
3 students said 'Always'
All students think that simulations should be used
Half selected 'Sometimes' or 'Rarely'
No-one said 'Never'

- Overall, students think that simulations should be used half of the time and I think the reason for this is that only about half of theories in physics are represented well with simulations. This proves that there is need for more simulations for physics practicals achieved to a high standard.
- No students were of the view that simulations should never be used.

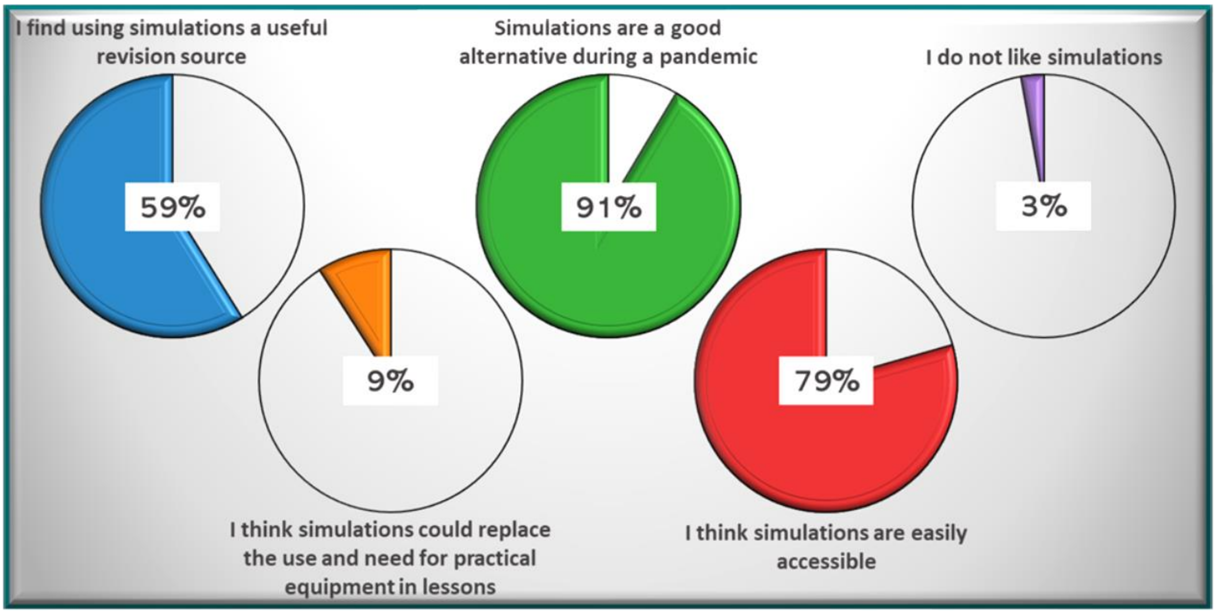
Question 8:

As a continuation to the above question *[Q7]*, Why do you think this?

- ‘As it stands, I do not have a large need for the use of simulations alongside the experiments I need to do, however the use of simulations can certainly be increased in either more complex or professional scenario, such as in university experiments.’
- ‘Simulations are only really the better alternative when the practical experiment has a very high error margin.’
- ‘Good to see what to expect for results.’
- ‘Because some are easier to understand when you are doing it yourself.’
- ‘Sometimes practicals don’t go to plan whereas simulations will always go correctly meaning they are more reliable and more useful.’
- ‘Practical teaches me properly on how to setup the equipment I will be using, and therefore would prefer to do practical.’
- ‘More accurate and less time consuming.’
- ‘Is faster, easier and uses less space than setting up a physical practical.’
- ‘Simulations are more accurate and less time consuming.’
- ‘Some practices are more interesting if you do it yourself.’
- ‘Some practicals may work best over a simulation; however, a simulation would work well for practicals as well.’
- ‘Sometimes they are particularly helpful for understanding concepts e.g. electricity that cannot be seen, but in general it is better to do practicals without a simulation.’
- ‘Comparisons between a simulation and real-life practicals could highlight experimental errors more easily.’
- ‘So you cans see what is happened.’
- ‘If doing practical physics, isn't much need to do simulations, and vice versa.’
- ‘Practical allows you to properly grasp every aspect of the experiment even if slightly inaccurate, simulations are good for showing how something works on paper, but you get less understanding than physically putting everything together.’
- ‘Haven't thought about using simulations outside of lesson.’
- ‘The simulations don't simulate what happens exactly.’
- ‘If there is time to do the practical then it can be more beneficial than a simulation, but a simulation can be useful in situations such as quickly showing how a electrical circuit might work for example, or being able to do experiments at home without having to have equipment.’
- ‘Practicals help give a more in-depth explanation and show the real-life effects of theory taught in lessons.’
- ‘I believe it is much better to do something practically as it demonstrates the laws at play whereas in a simulation, laws do not need to exist.’
- ‘I like simulations because they allow me to do a practical and understand it at my own pace.’
- ‘I selected Always because I think simulations are a good tool to look back at a practical and I think they should be used together.’
- ‘I think people can learn better in person.’
- ‘Better to see where the results come from in real life.’
- ‘You learn practicals more from participating in them and not watching a simulation however for some practicals which are complicated simulations can help explain them.’
- ‘Easier to understand a new concept. Understand it quicker.’
- ‘Less preparation and physical space is required for simulations.’
- ‘I think simulations are a good way to understand a practical!’
- ‘Simulations are fun to experiment with different and extreme values’

Question 9:

Please select any of the following that apply to you:



Most students think that simulations are a good alternative during a pandemic

The majority of student believe simulations are easily accessible

Only 1 student said they didn't like simulations

Very few said they think simulations could replace the use and need for practical equipment in lessons

59% said they find using simulations a useful revision source

Overall…

- …students think that using simulations is a useful revision source.
- …students doubt simulations could replace the use and need for practical equipment in lessons.
- …students believe that simulations are a good alternative during a pandemic.
- …students say simulations are easily accessible.
- …students like simulations.

Question 10:

If there are any aspects of simulations that you think would benefit you that do not already exist, or have any further comments on the use of Simulations as opposed to Practical Physics, please state them here...

- 'Allowing more interaction and personalisation with different practicals and making them as realistic as possible e.g. taking into account things like air resistance.'
- 'Simulations are especially good for when a task is monotonous or just impractical for a person to carry out, but the use of physical experiments is a good way to reinforce and ground a physics concept in reality since there can be no "strings attached" in a sense: While I do think that simulations are the way to go for complex experiments, the physical experiments are still a very reliable, widely tested and challenged, so I don't think they should be preplaced by simulations any time soon in education unless it is more convenient.'
- 'More functions and larger range of values you can use.'
- 'It's easier to see subtle changes that would happen in an actual practice although I feel that practices are very much necessary as required practices are assessed and due to only using simulations you would lack practice skills.'
- 'For navigating the simulation, it depends on the simulator itself I believe that an easy to navigate simulator should have an easy to navigate and a non-ambiguous GUI.'
- 'If the equipment isn't available or the physics need to be demonstrated outside of the lab (at home), simulations are a good alternative for this.'
- 'Simulations should display the calculations behind the physics.'
- 'I would benefit from more required practicals having a simulation alternative.'
- 'Navigating simulations is sometimes difficult so it would be nice if there was a simulation that was easier to interact with.'

Overview of Opinions

"I like simulations"

"...simulations are good for showing how something works..."

"Is faster, easier and uses less space than setting up a physical practical"

"...could highlight experimental errors more easily."

"Sometimes practicals don't go to plan whereas **simulations will always go correctly** meaning they are **more reliable** and **more useful**."

"More accurate and less time consuming"

"Good to see what to expect for results"

"If the equipment isn't available or the physics need to be demonstrated outside of the lab (at home), simulations are a good alternative for this"

"...a simulation can be useful"

"...they allow me to do a practical at my own pace"

From the results of the survey, it is clear to see that students tend to prefer simulations. Students like them because they are: easy to use and navigate; a great alternative during a pandemic; easily accessible and a useful revision source. They also stated that 'sometimes practicals don't go to plan whereas simulations will always go correctly meaning they are more reliable and more useful.' As well as being, 'More accurate,' 'less time consuming,' are 'faster, easier and use less space than setting up a physical practical.'

These positive views of existing simulations prove there are definite qualities that I need to consistently maintain during the design process and the making of my program, focusing especially on being easier to use and faster to execute than a physical practical. However not one student said they disagreed that simulations could be improved for the benefit of students, and most were hesitant to say that simulations could replace practical physics.

Some of the suggestions that were made were:

- *'Allowing more interaction and personalisation with different practicals and making them as realistic as possible.'*
- *'More functions and larger range of values you can use.'*
- *'I believe that an easy to navigate simulator should have an easy to navigate and a non-ambiguous GUI.'*
- *'Simulations should display the calculations behind the physics.'*
- *'I would benefit from more required practicals having a simulation alternative.'*
- *'Navigating simulations is sometimes difficult so it would be nice if there was a simulation that was easier to interact with.'*

I will aim to include all these suggestions of potential improvements within my program as, I believe that it is important to understand the desires of the target audience, here being A-level physics students and to deem this project as a success I need to improve from current simulation alternatives based off up-to-date constructive opinions of simulations.

The Approach

In the creation of this project, to achieve my aim of creating a program containing simulations for the benefit of A-level students, I could take multiple different approaches which include:

- Creating a program that focuses on only a small number of practicals but in addition to this, includes the methods for which the student could carry out the corresponding practical in person. This approach will aid the students in a more precise way for specific practicals which will be more beneficial for some students but for the vast majority will most likely require more simulations in the program.
- Designing and making a program that is more based on quantity and combines most of the practicals yet will aim less to demonstrate the methodology for the physical practical. This approach allows the students to have a full overview of all practicals which will allow them to rely on the program more, yet this will require the student to do their own individual research if they wish to learn more in-depth ideas and theories relating to the practical which some students may not appreciate.
- The simulations could be very equations based and emphasise on helping the student understand the calculations behind the simulation. This will help the students with the mathematical side of all practicals which will help them more in preparation for scientific calculation style questions in their end of year exam. However, if the student is confident with their maths skills, then they may not find the need to use the program and it may not be as valuable for them to use.
- A visual format for the simulations involving animations and simple designs to appeal to the student more. Doing this will ensure that student engagement is higher as they will find the simulations easier to use, reducing stress, especially when revising.

Based off the 'Survey' and students' responses the approach will be that of being visually appealing using appropriate colours/images and including animations and moving parts to the simulations. Since many students, during the 'Survey', illuded to the fact that they like simulations practical for the convenience and the idea that they are 'more accurate and less time consuming' I will make sure to simplify the design also and have clear indications as to reference how to use the simulations. It is also important that refer to the equations used in the calculations so they will also be a part of each simulation. I further wish to include additional parts to the program related to physics equations, as most students agreed that they enjoy using simulations as a useful revision tool.

Integrated Development Environment

What IDE am I using?

For the creation of the project 'Visual Studio 2022' will be used as the IDE. The benefits of visual studio are that it is free to use, meaning students will not have to pay to install any software on their personal devises to have access to the product of this project. It also provides a user-friendly interface within which the user will find it much simpler to initially run the program than if the program was written using a different IDE. Another benefit of 'Visual Studio 2022' is that it is the latest version of Visual Studio as of this program being made, meaning the most up to date software is within. Also, Visual Studio provides cross-platform support meaning students can use either 'Windows', 'MAC' or 'Linux' systems and still have the ability to run the program and use the simulations.

Visual Studio is also very useful from a programmers perspective as it is very developed, the first version being over 25 years old. This means that the likelihood of there being issues with the software very slim. Visual studio also offers a very simple to use interface for the programmer, allowing them to drag and drop objects onto form designs, making the design of a simulation much faster to create meaning more time can be spent of the efficiency of the code meaning creating a smoother experience for the student.

What programing language am I using?

I will be using 'Visual Basic' as the programming language for the program. 'Visual Basic' was developed by Microsoft and was first released 31 years ago. As the name would suggest, this language provides a 'Basic' interface with the purpose of making is easier to read/use than other programming languages meaning the speed of which code can be written is much quicker, making the program faster to write than if another language was to be used.

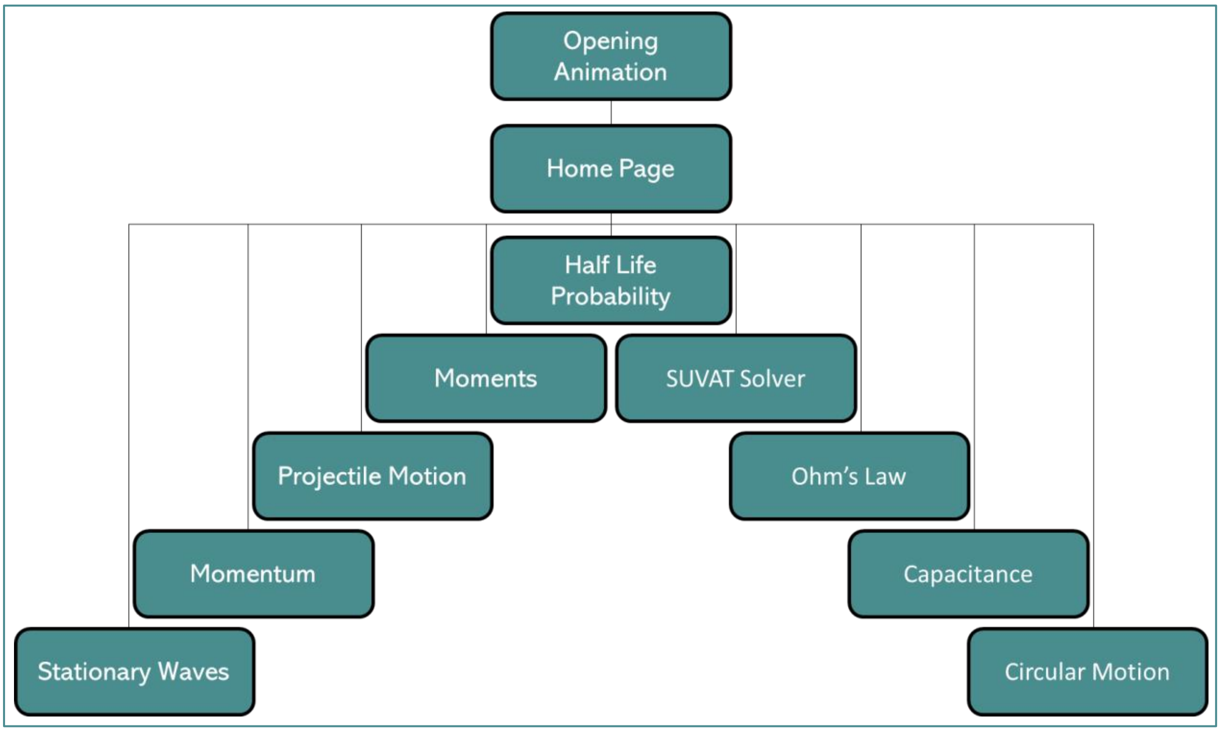
Simulations

I plan to include 9 simulations in my project, all covering different areas of A-level physics with the aim to benefit A-level physics students. The first simulation would be representative of the 'Stationary Waves' practical. During research it developed that this practical is very visual and would be a useful simulation for the students to use, instead of having to rely on manual calculations with the 'Harmonic' equation. The survey gave light to the fact that students 'like simulations' because they are 'good to show how something works'. From this, I believe animating the theory of collisions and momentum in a simulation format will be very beneficial to the students as this would take up lots of time to set up with the correct apparatus which reduces to almost immediately with the use of a simulation. Another simulation that could be a useful addition to the program for students could be a 'Projectile Motion' simulation as, this is not something that can be replicated easily in a classroom and so will be very useful for students to have the ability to visualize this idea, outside of only equations. The idea of 'Moments' is another simulation that could be added to the program as this again is not easy to replicate as, if apparatus was setup to display moments in person, the system would likely only last a few seconds if the system was unbalanced yet with the use of a simulation, a student can view a system that is unbalanced for as long as they wish. The idea of the probability of a half life with radiation, if setup practically, isn't easy for students to visualise, and the fact that simulations help with the visualisation of certain theories in physics was brought up by multiple students in responses to the survey. Due to this, a corresponding simulation for this practical could help students understand the theory more, providing a useful revision source for them. Because simulations can calculate/formulate answers much quicker than students can, a useful source could be a simulation that solves 'SUVAT' equations. These are commonly used in projectiles and this simulation could be beneficial to use alongside a practical setup for a student to crosscheck the accuracy of their answers. Ohms law is also a simulation that could be very visual and helpful for the students to be able to view in the form of a simulation within the program, so that will be another addition. A practical that is centred around a graph is the 'charging and discharging of capacitors' which takes time to gather results for and, the survey obtained that 'simulations save time' meaning this practical would be useful if it was converted to a simulation. There are many equations that are used for the idea of 'Circular Motion'. This idea, as a practical, is very visual yet isn't easy to setup and gather accurate results from therefore, because a simulation is 'more accurate and less time consuming', I believe students would appreciate if this practical was to be translated into an easy-to-use simulation for the benefit of revision and A-level students.

User Interface

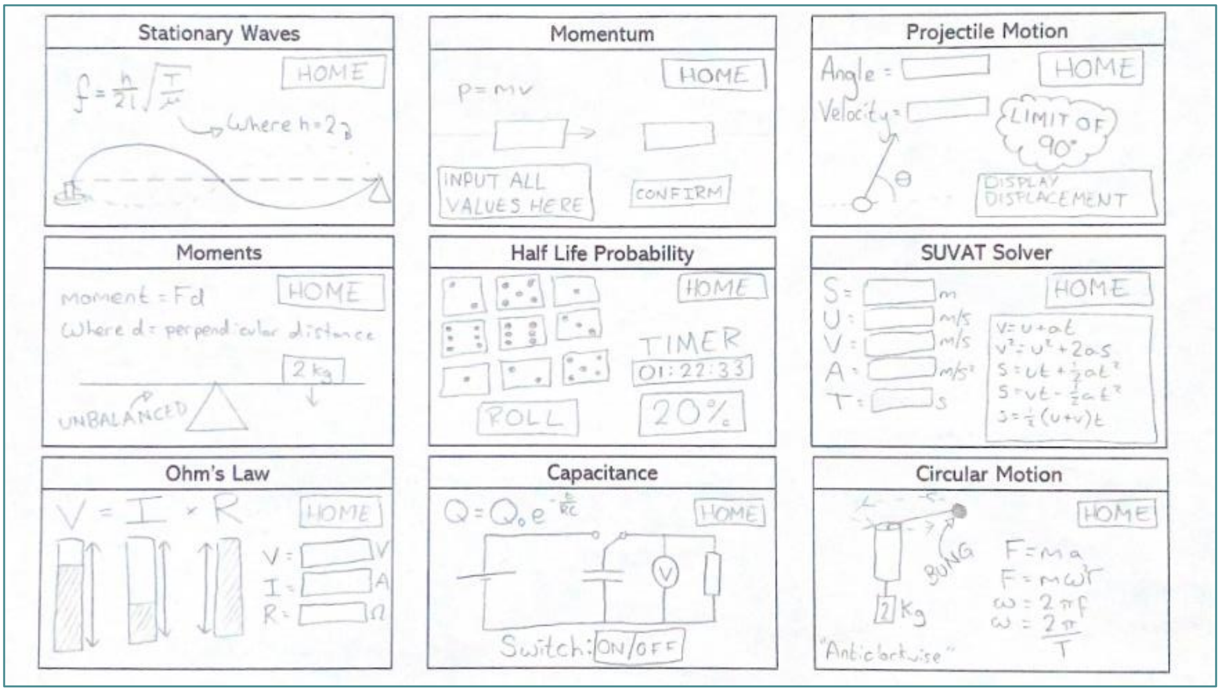
From the results of the survey, it is clear to see that students want an easy to use and navigate program and that is one of the main qualities of simulations. Due to this, animations are required and must be included for the user to feel more immersed for some of the simulations, such as the 'Stationary Waves' simulation. To improve navigation, there is a need for a 'Home Page'. This will provide a positive first impression and, if executed well, with have a clean, simplistic look that should appeal to the students when using the program. The page should consist of 9 buttons, one for each simulation, that when pressed change the display to the corresponding simulation. This also means though, that there must be a way for the student to navigate ack to the 'Home Page' from each simulation, therefore there must be a button somewhere on each simulation display. Another addition that will be made to improve the user interface and enhance the experience the user has when using the program would be an animation to be played before the program opens the 'Home Page'. This will set the tone for the program and will professionalise the design of the program.

Structure Chart



The above chart shows the structure of the program from a user interaction point of view by displaying the first entered section at the top, being the 'Opening Animation', followed by the 'Home Page' and all 9 simulations are to be navigated from the 'Home Page'

Initial Ideas



The above image shows the initial ideas for each simulation design along side the equations that may be used and layouts that were first considered.

Opening Animation

Figure 1

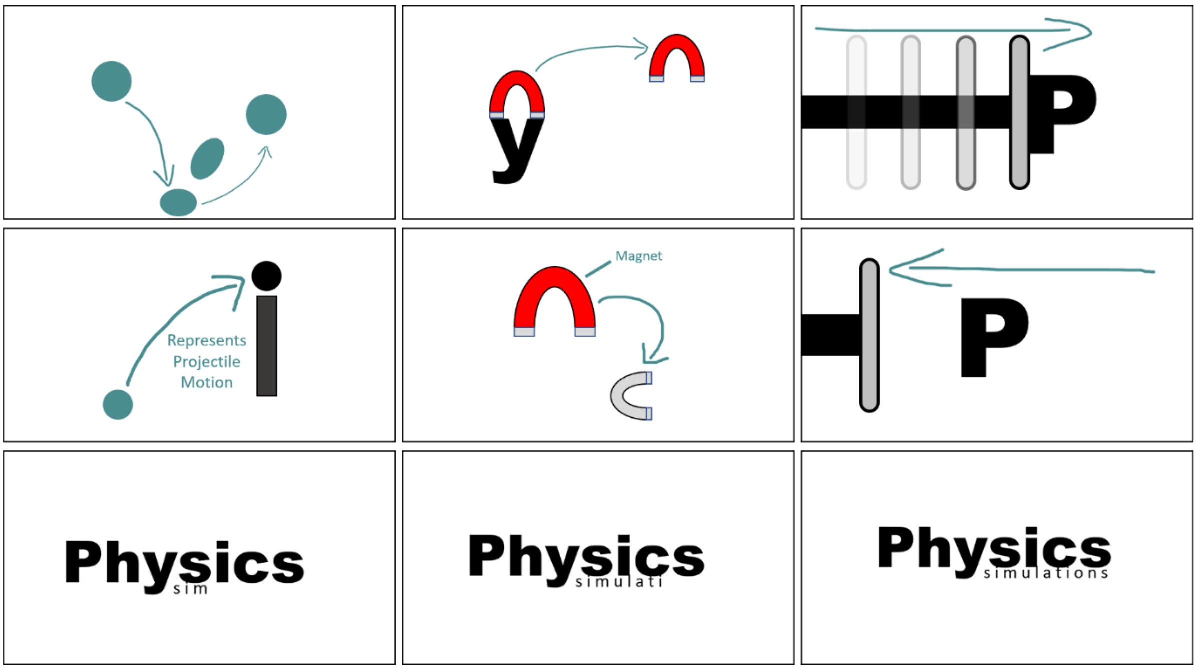


Figure 1 shows the design for the 'Opening Animation' which will be the first part of the program that the students can see. This design will act as a storyboard when creating the final product as the result will be in an animation format. I have attempted to incorporate different elements of physics that will be recognizable to the users of the program to tie the program together by reiterating the physics theme not only in words but visually too. One physics idea that I have encompassed within the animation is that of projectile motion where I will attempt to animate the 'tittle' of the letter 'i' in the word 'Physics' by projecting and bouncing the dot from off the screen to its location within the design. Meanwhile, I plan to animate a magnet carrying the letter 'y' into place showing the idea of magnetism as, I will also fade the colour of the magnet as the letter is released and dropped into place, symbolising the loss of magnetism. This once magnet will then fall itself onto the letter 'y' at such an angle that it will roll clockwise to the right where it will fall into the position of the letter 'c' in physics. Moreover, from this design, it is my intention to push the letter 'P' into place from off screen using a piston like shape portraying forces in action. Once the word 'Physics' is then displayed onto the display, the word 'simulations' will then fade into the screen letter by letter with random motion, representing gas particles. By this point, the name of the program will be in full view for the students to see and so the title should stay for between 2-5 seconds before transitioning and re-directing the user of the program to the 'Home Page'.

Turn to page 32 for the result

The Home Page

Figure 2

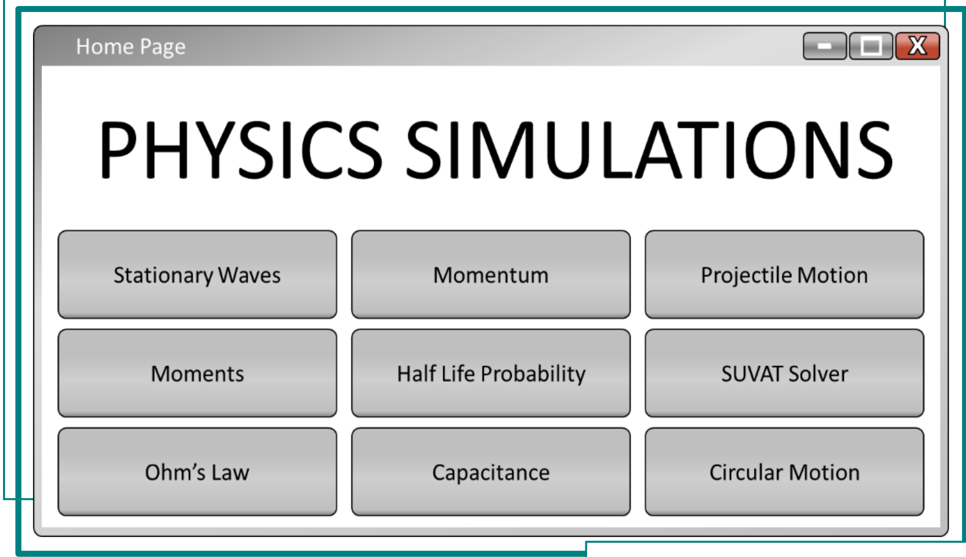


Figure 2 shows the design for the 'Home Page' form. I have included 9 buttons for easy navigation to the individual simulations within the program.

Figure 3

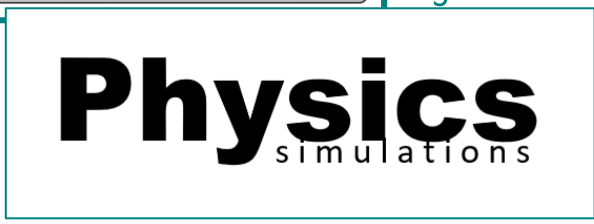


Figure 3 displays an alternative title design that is also an option for the final program. The text is bold to be more eye-catching, which will engage the student within the program.

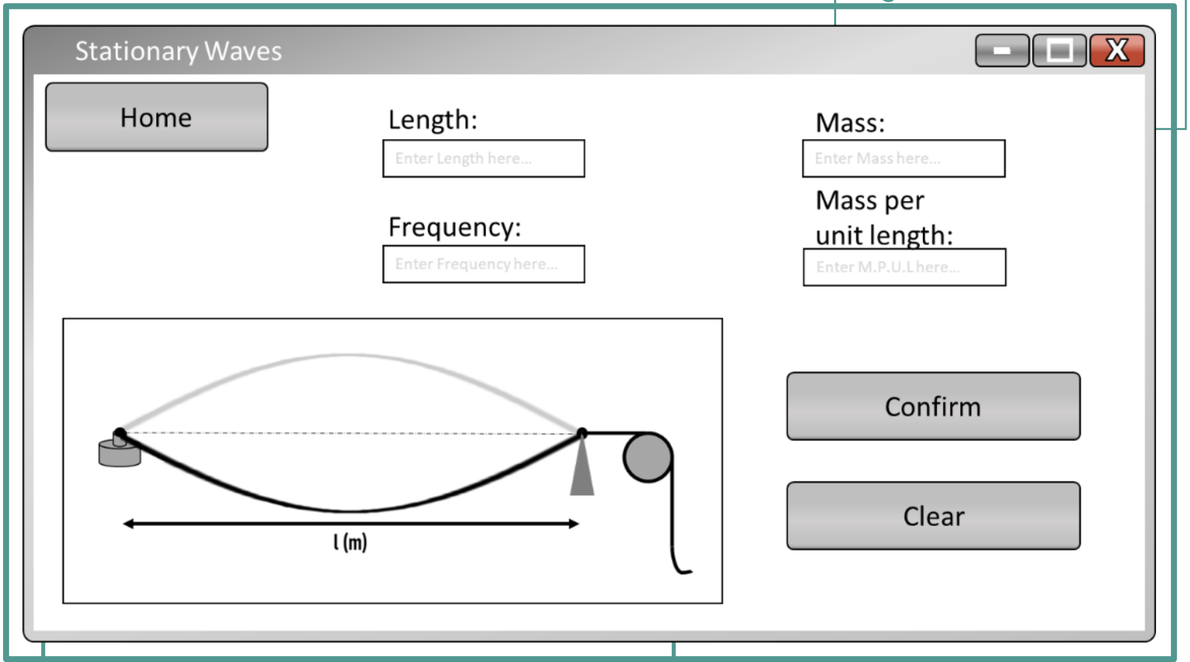
```
Sub StationaryWavesButtonPressed()
            Form_HomePage.Hide
            Form_StationaryWaves.Show
End Sub
```

The pseudocode above will be used for when the user presses the button marked 'Stationary Waves' and will send them to the Stationary Waves form by first hiding the current form and them showing the form that is wanted. This idea will be replicated for all buttons to access all forms.

Turn to page 33 for the result

Stationary Waves Simulation

Figure 4



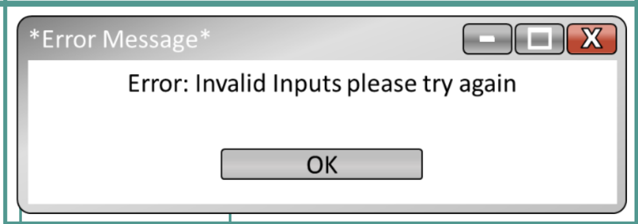


Figure 5

Figure 4 shows the design for the Stationary Waves Simulation Form. I have included a 'Confirm' button to confirm the inputs of 3 textboxes and a 'Clear' button to clear the contents of all 4.

Figure 5 is the error message that will be displayed if any of a few conditions are met when 'Confirm' is pressed:

1. There are less than 3 textboxes with values in them
2. There are no textboxes left empty
3. The contents of the textboxes are not integers/decimals

This pseudocode represents two subroutines. The first is entered to check if the inputs are valid as the values are being assigned to variables. If invalid, it will be noticed in the second subroutine and Error will be set to 'True' which will later cause the error to be displayed.

```
Sub AssignValues()
        InvalidInputs = False
        Try
                Length = Textbox_Length_Text
                Frequency = Textbox_Frequency_Text
                Mass = Textbox_Mass_Text
                MPUL = Textbox_MPUL_Text
        Catch
                InvalidInputs = True
        End Try
End Sub

Sub CheckForErrors()
        Error = False
        If NumOfTextBoxesEmpty <> 1
                Error = True
        ElseIf InvalidInputs = True
                Error = True
        End If
End Sub
```

Turn to page 34 for the result

Momentum Simulation

Figure 6

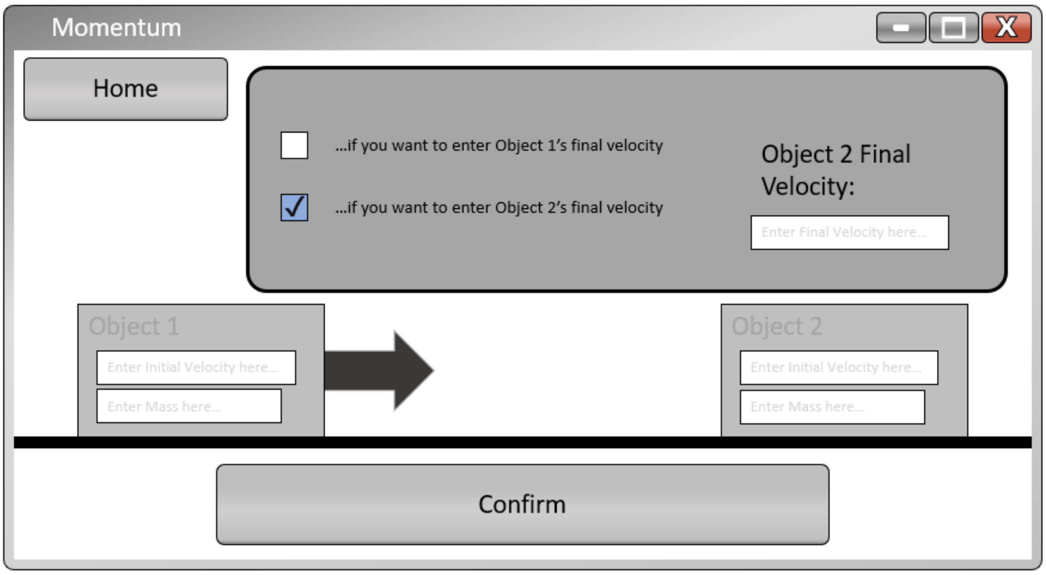


Figure 7 displays the design for the 'momentum' simulation. There are only 2 buttons on this design, one to redirect the user to the 'Home Page' and the other to 'Confirm' the inputs from the student. The idea behind the format of this form is that the student inputs the initial velocity and mass for each object followed by a chosen final velocity for an object. Then a student can press the 'Confirm' button.

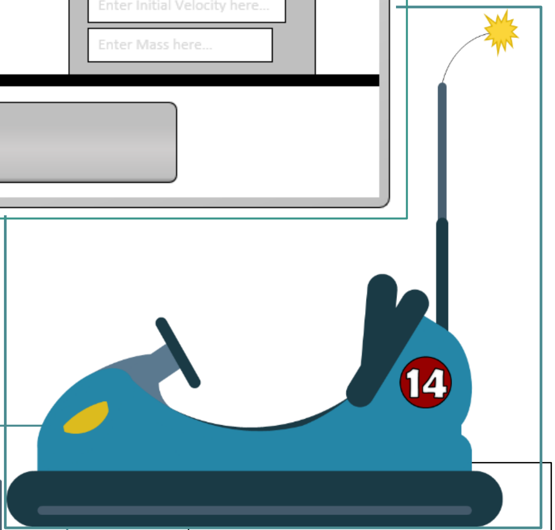


Figure 7

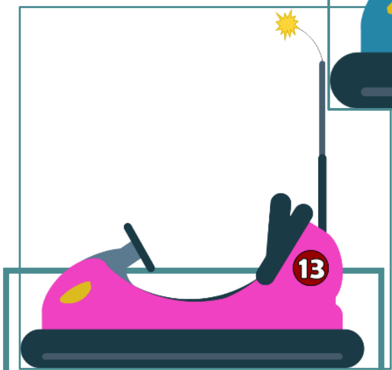
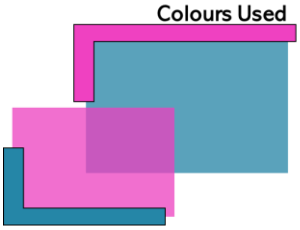


Figure 8

Colours Used



Both, figures 7 and 8 display an alternative format to display the function of momentum and collisions. This representation is more vibrant, colourful and relatable to the student because it is most likely an example of a collision that they have seen in person which is difficult to replicate in a physics lab easily. I designed these dodgems with a simplistic design to also appeal to the clean look of the rest of the simulation.

Turn to page 35 for the result

Projectile Motion Simulation

Figure 9

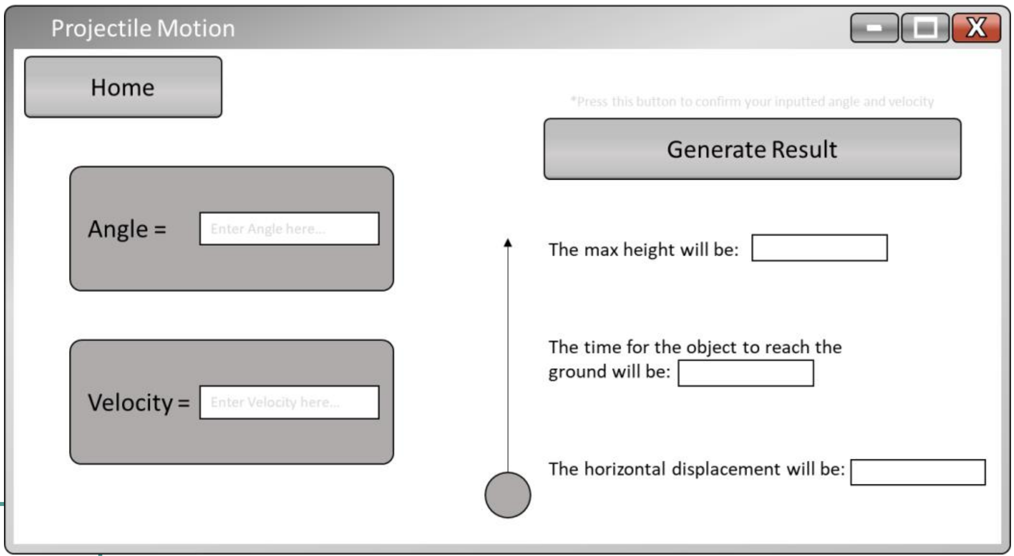


Figure 10

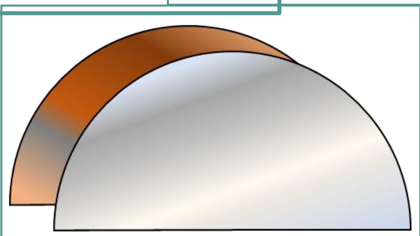
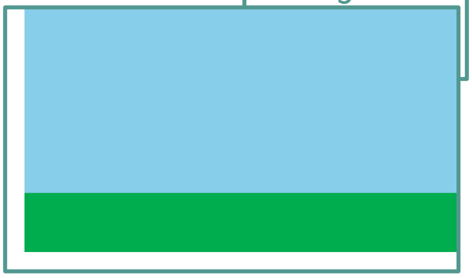


Figure 9 displays the form design for the 'Projectile Motion' form. I have only included one additional button to the 'Home' button to increase the simplicity of the form and reduce user confusion when using the simulation. Also, there are two very clear inputs on this form to further the idea of not complicating the form.

Both figures 10 and 11 show possible ideas for surface ideas that the object could be projected from. Figure 8 focuses on the surface of different planets, as I could later add that to the form and allow the user to choose their surface which would change the values outputted due to differing 'acceleration due to gravity' values. Figure 9 represents the surface of the earth and is more simplistic to not distract from the object and the outputs which should be the focus of the user.

Figure 11



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Moments Simulation

Figure 12

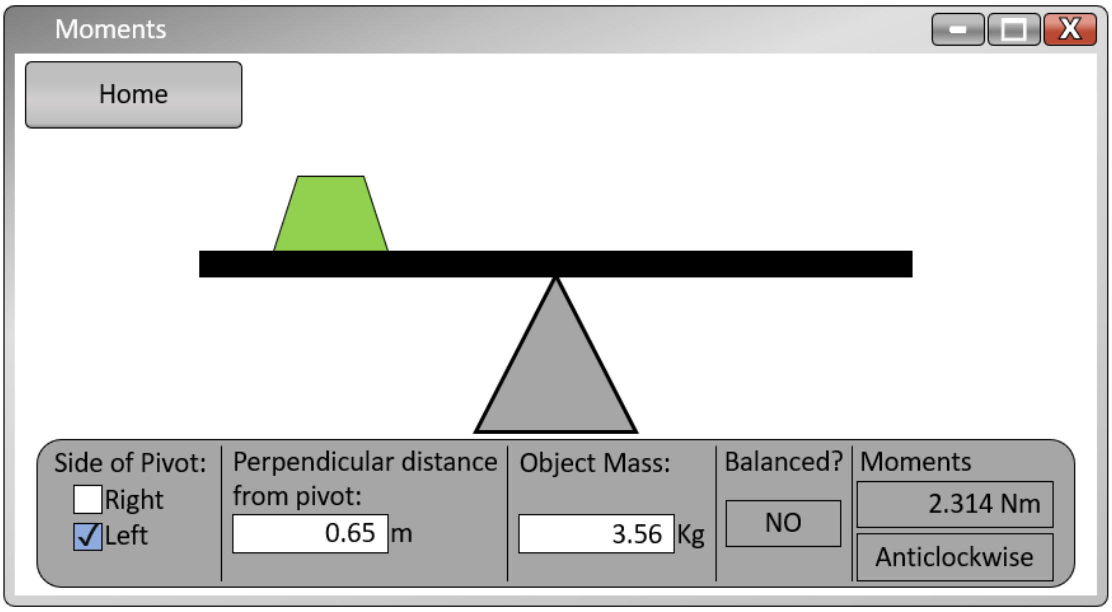


Figure 12 displays the design for the 'Moments' simulation. It takes a simplistic approach to a potentially complex system by reducing all text to the bottom of the display. There is also one button to navigate back to the 'Home Page'. The student can also interact with the form using the checkboxes to select which side of the pivot the object is on and there are also 2 textboxes to allow the user to input the mass and distance that the object is from the pivot.

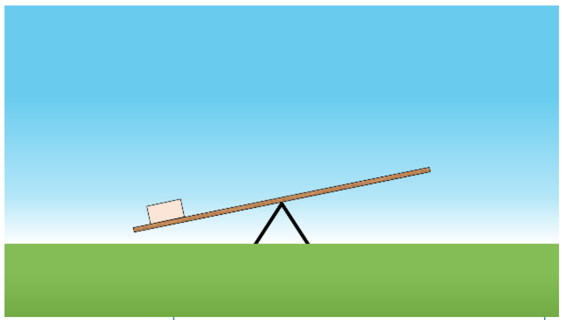


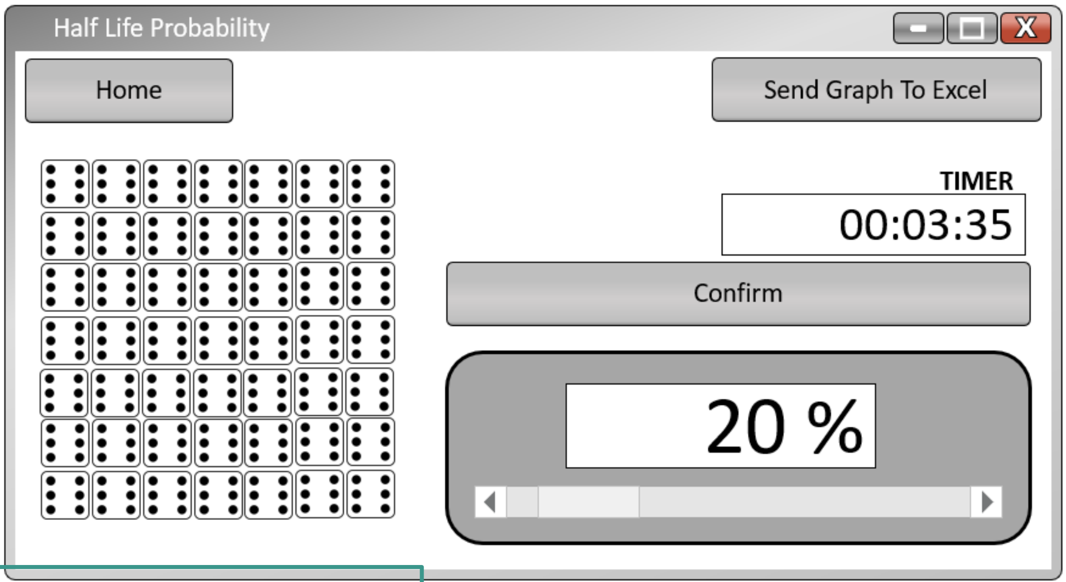
Figure 13

Figure 13 is an alternative visual representation of what the system could look like. It looks more visually appealing due to the addition of vibrant colours but also the relatability of the setup as the background represents a grass-like ground with a gradient sky horizon. Also, the system in the foreground resembles a 'seesaw' more than the system in the design in figure 12 which every student will have seen and recognise.

Turn to page 37 for the result

Half Life Probability Simulation

Figure 14



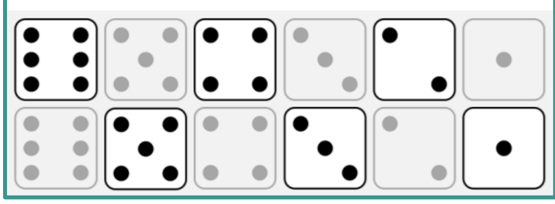


Figure 15

Figure 14 shows the design for the 'Half Life Probability' simulation. The display includes 3 buttons. The first button, like every simulation is the 'Home' button which, when pressed, will direct the user to the 'Home Page'. The 'Confirm' button will confirm the inputs from the student and roll the dice. Finally, the 'Send Graph To Excel' will send the data from the simulation to a 'Microsoft Excel' spreadsheet which will also create a corresponding graph for this simulations which will be useful for students to interpret trends from. There is also a 'TIMER' on the form to replicate the practical done in person which requires a stopwatch.

Figure 15 displays the different variations of dice that can be displayed within the 7x7 display. Each side of the dice are displayed from numbers 1-6 yet there are two versions of each, one black and white, and another that is grayed out to signify if the dice is going to be used on the next roll or not.

Turn to page 38 for the result

SUVAT Solver Simulation

Figure 16

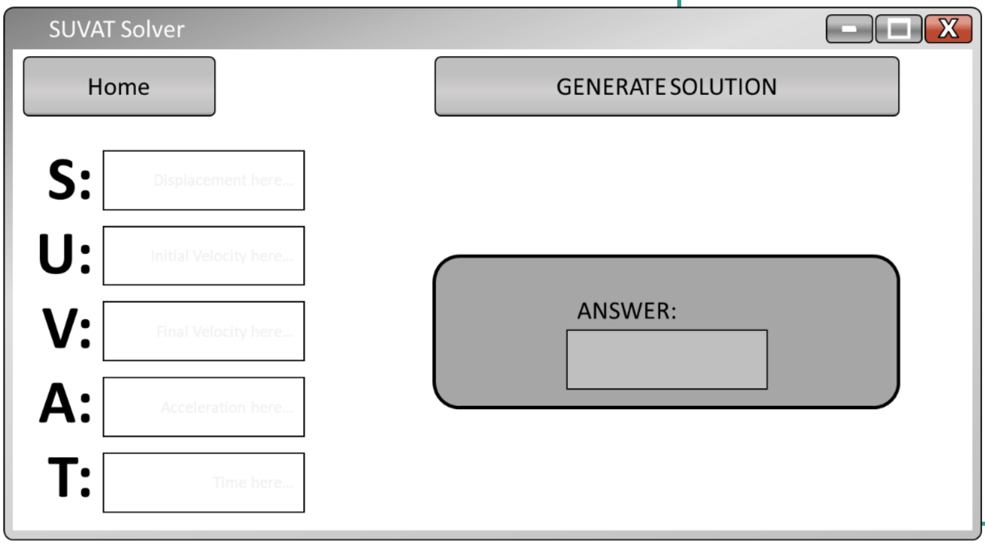


Figure 16 shows the design of the 'SUVAT Solver' simulation which is a very simplistic design as this simulation is very equation based in the background in the code. There is only 1 button in this display that isn't the 'Home' button and that is the 'GENERATE SOLUTION' button, this button confirms the students inputs and if the inputs are valid then there will be an answer displayed yet if there isn't then there will be no answer displayed and an appropriate error message will be displayed.

```
Sub CheckValidDisplacementInput()
        If Textbox_S_Text = "?"
                WantedValue = "S"
        If Textbox_S_Text = ""
                DisplacementUsed = False
        Else
                Try
                        DisplacementValue = Textbox_S_Text
                        Exit Sub
                Catch
                        OUTPUT = "Invalid Input for Displacement"
                End Try
        End If
End Sub
```

This pseudocode represents one subroutine where the structure will be repeated for each of the 5 variables in SUVAT equations (Displacement – S | Initial Velocity – U | Final Velocity – V | Acceleration – A | Time – T). The purpose of the subroutine is to validate whether the input will work in an equation or to determine the equation necessary. It first checks to see whether or not the contents of the textbox is a question mark which is the symbol that the student must enter into the textbox if they wish to have that variable as the answer. This is important also because it determines in which way to re-arrange the specific equation. The equation is determined by the given values for variables and so if the textbox for a variable is blank, then it cannot be used, later, in an equation because it would result in an error. Finally, if the textbox contents are neither blank nor a question mark then an example of 'exception handling' is used with a Try-Catch statement. This checks whether the inputs are invalid e.g., a character instead of a float/integer and if invalid will output an appropriate error message. However, if the value is valid then the value will be stored in a corresponding global variable.

Turn to page 39 for the result

Ohm's Law Simulation

Figure 17

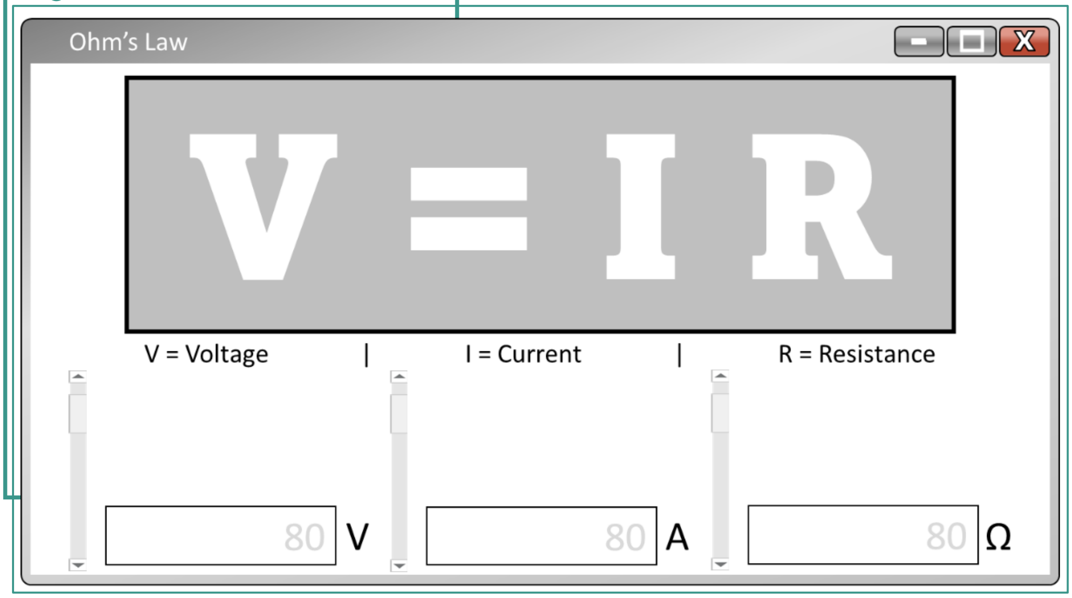
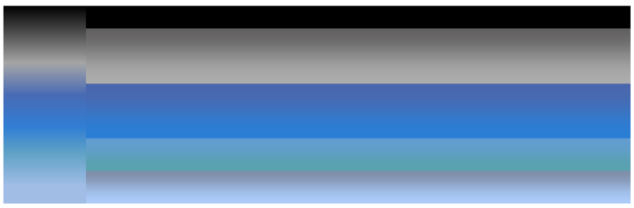


Figure 17 shows the design for the 'Ohm's Law' simulation. Although not displayed here, I plan to have one button on this form being a 'Home' button to direct the student to the 'Home Page' if they press it. Currently though there are just three sliders for the user to interact with. These sliders work by having a maximum and a minimum value. The maximum number being outputted when the 'scroll box' is at the top of the 'scroll bar' and the minimum being when the 'scroll box' is at the bottom. These values are then displayed in textboxes along side their appropriate units and if changes are necessary to other values, then they are made.

The simulation required a colour that makes the design look more visually appealing but to not distract from the simulation so I designed 2 colour palette options, one of which will be in the final simulation.

Colour Palette Option 1

Colour Palette Option 2



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Capacitance Simulation

Figure 18

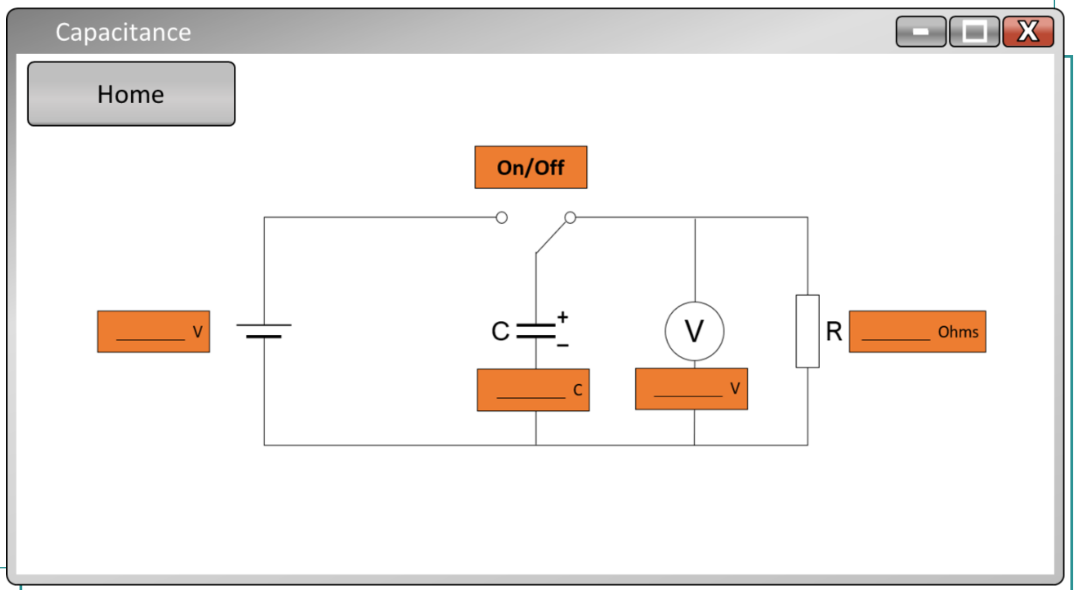

Figure 19

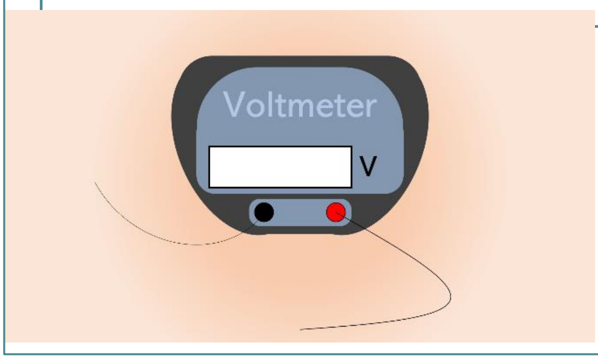

Figure 18 shows the design for the 'Capacitance' simulation containing only two buttons, one being the 'Home' button to direct the student to the 'Home Page' and the other to toggle the switch on and off within the circuit. The rest of the simulation works with the use of textboxes where the student will input the values of the battery voltage, the capacitance and the resistance and when the student then pressed the toggle button for the switch, the voltmeter value will change with time, replicating how a capacitor would charge and then discharge.

Figure 19 represents an alternative approach to the design of this simulation being a more visually recognisable system with images and more colours as opposed to just a circuit diagram. This image is of a voltmeter but if this approach was to be used, a capacitor, battery and resistor could also be designed and connected with wires to each other to further improve the layout and design of this simulation.

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Circular Motion Simulation

Figure 20

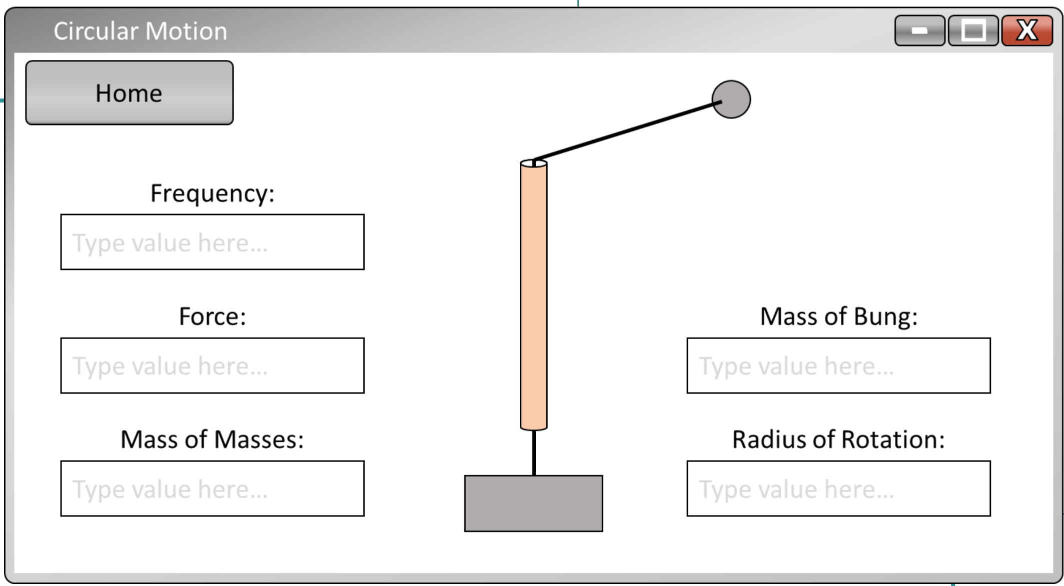


Figure 21

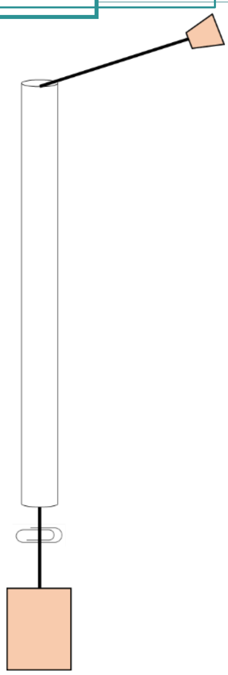


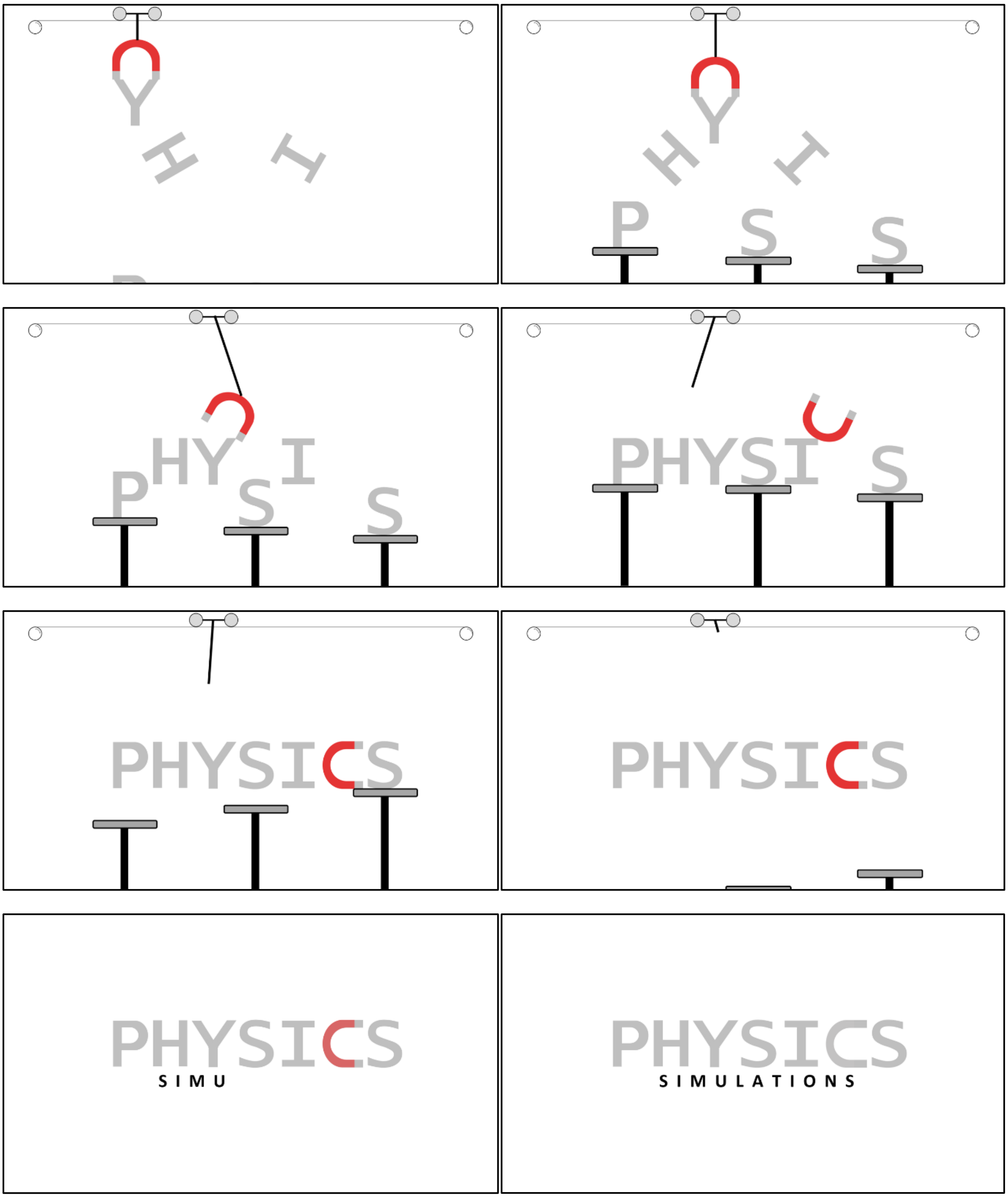
Figure 20 displays the design for the 'Circular Motion' simulation which is composed of only one button being the 'Home' button, consistently being placed in the design of every simulation to direct the student back to the 'Home Page'. The rest of the design is the system in the centre of the design which will animate by spinning replicating the motion of the practical if carried out in person. The rest of the design is 5 textboxes which the student can use to type in their inputs and view their answer if the program can calculate one from the given inputs.

Figure 21 shows a different and substitute design for the system which could be used as a more accurate version compared to the apparatus required in the physical practical. This version also uses a paperclip as a marker point which is required and the bung is a more realistic shape as it would be.

Turn to page 42 for the result

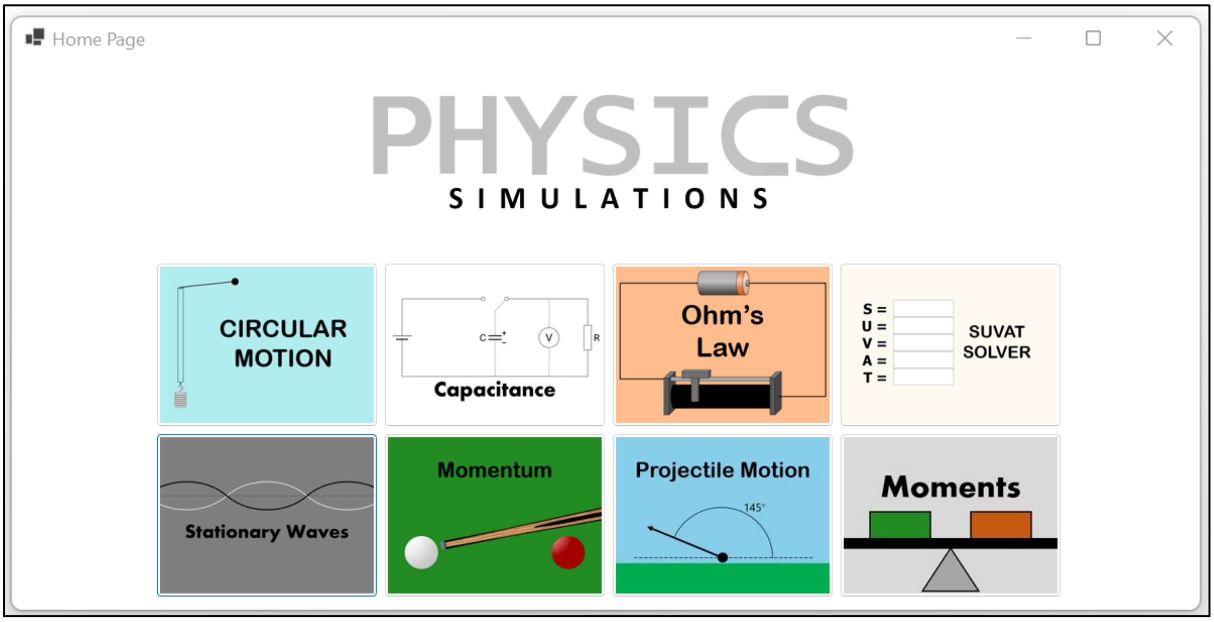
Opening Animation

Video - https://youtu.be/3Sg_pWEB2rc



The Home Page

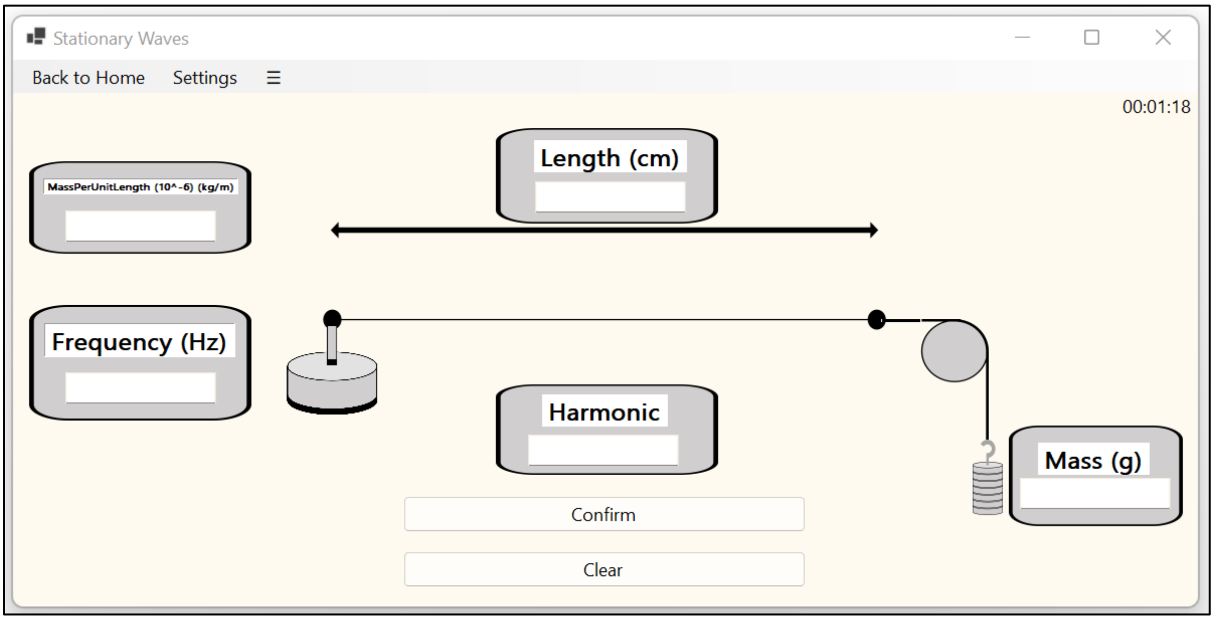
Video - https://youtu.be/md2goOrHozc



This is the final result of the 'Home Page'. Due to the fact that one of the practicals was not used in the final program, being the 'Half Life Probability' simulation, it isn't represented in the design of this page. This means that there are a total of 8 buttons which all have a representation of the simulation in the form of an illustration to colourise the 'Home Page' making the overall visual appeal greater and also, providing a good first impression for each simulation, showing that each is unique as all of the simulations and their representations are individual/different from one another. Furthermore, the final status of the 'Opening Animation' which are the words 'PYSICS SIMULATIONS' are also displayed centrally here which creates a clean and professional transition from between the two parts of the program.

Stationary Wave Simulation

Video - https://youtu.be/27557aL_CRc



- About

This simulation has been designed with the intention of displaying a stationary/standing wave, up to, and including, the fifth harmonic, specific to the user's 4 inputs whilst also, calculating an additional component of the harmonic equation.

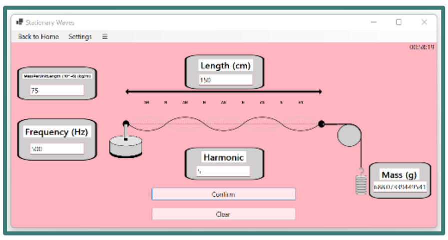
How To Use -

To effectively use this simulation, you must have 4 inputs to insert into the corresponding textboxes (considering the scale of units). If 'Confirm' is pressed, the inputs will be calculated and if they are valid, then a fifth value should be outputted into the empty textbox. If 'Cancel' is pressed, all inputs will be removed from all textboxes.

- Equipment Used

List of Equipment:
Signal Generator: To measure frequency of the harmonic and operate the vibration generator.
Vibration Generator: Vibrates to cause a stationary wave.
String: Used to observe stationary wave.
Pulley: To allow the masses to hang vertically and reduce friction.
Masses: To provide a tension in the string.
Metre Ruler: To measure the length of the string.
Top-Pan Balance: To meausre the mass of the string to calculate it's mass per unit length.

Equation Used -



The Harmonic Equation:

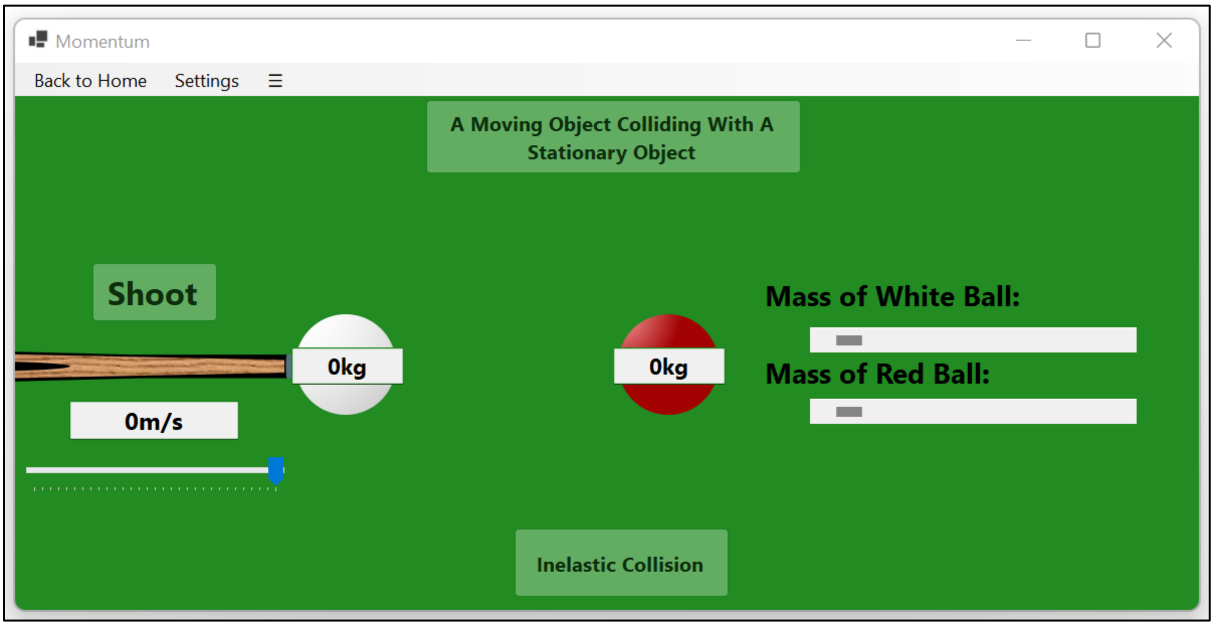
$$f = (n / (2 * l)) * \sqrt{(T / \mu)}$$

Where:

f = frequency of vibration generator
n = harmonic number
l = length of vibrating string
T = tension provided by the masses
μ = mass per unit length of the string

Momentum Simulation

Video - https://youtu.be/HTqqXFeViSc



This simulation has been designed with the intention of displaying what occurs when a moving object collides with a stationary object, depeding on the momentum of both objects.

- About

How To Use -

To effectively use this simulation, you must first, use the 3 sliders to change the initial velocity of the 'White Ball' and the mass of both. Then you will be able to press shoot and if you do you will be asked to input the final velocity of either ball which will then display the final outcome during collision using a visual trajectory of the balls and textboxes to either side displaying the velocity of each ball. If you wish to reset the simulation, press 'RESET'.

Momentum Equation:

$$p = m * v$$

Where:

p = momentum of an object
m = mass of an object
v = velocity of an object

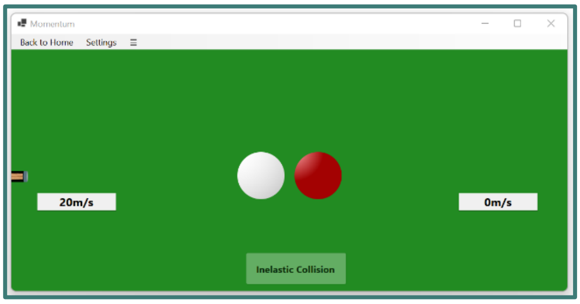
Conservation of Momentum:
(Total Momentum Before = Total Momentum After)

$$(M1 * IV1) + (M2 * IV2) = (M1 * FV1) + (M2 * FV2)$$

Where:

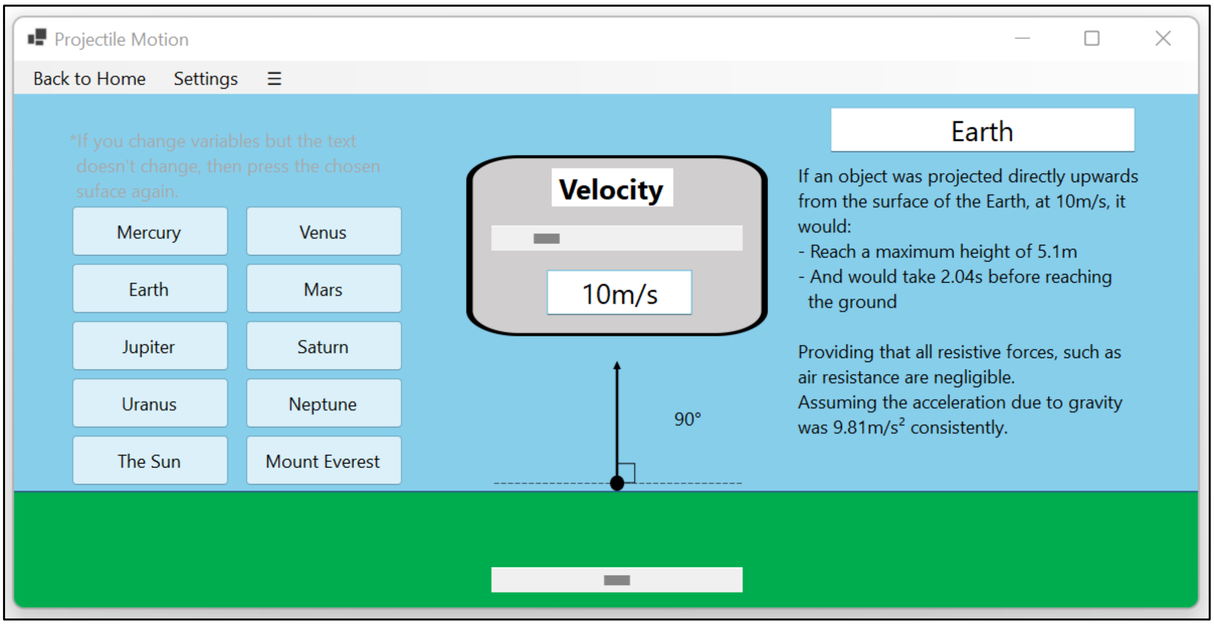
M1 = mass of object 1
IV1 = initial velocity of object 1
FV1 = final velocity of object 1

- Equations Used



Projectile Motion Simulation

Video - https://youtu.be/DmRIbzOH-yM



This simulation has been designed with the intention of displaying the result of when an object is projected at a user defined angle and velocity, from a surface, also chosen by the user

- About

How To Use -

To effectively use this simulation, you must use the two sliders to set the angle and velocity that the object will be propelled at. Then you must select from one of the ten buttons on the left, which determine the surface from which the object would be propelled from. If you have made changes and no information, on the right, changes then re-press this button.

SUVAT Equations:

$V = U + AT$

$V^2 = U^2 + 2AS$

$S = UT + \frac{1}{2}AT^2$

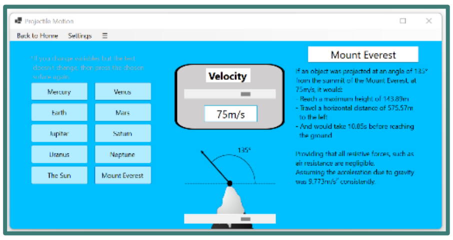
$S = VT - \frac{1}{2}AT^2$

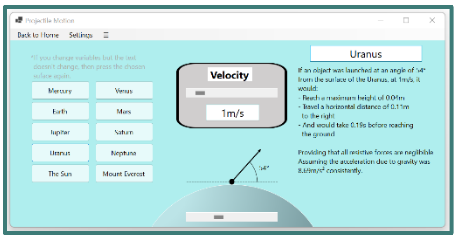
$S = \frac{1}{2}(U + V)T$

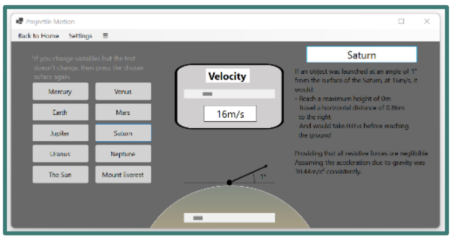
Where:

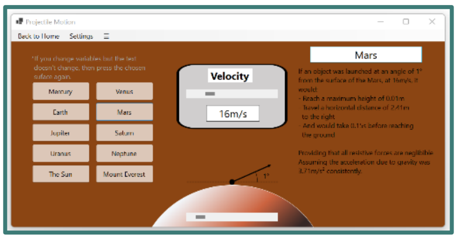
S = displacement
U = initial velocity
V = final velocity
A = acceleration
T = time

- Equations Used



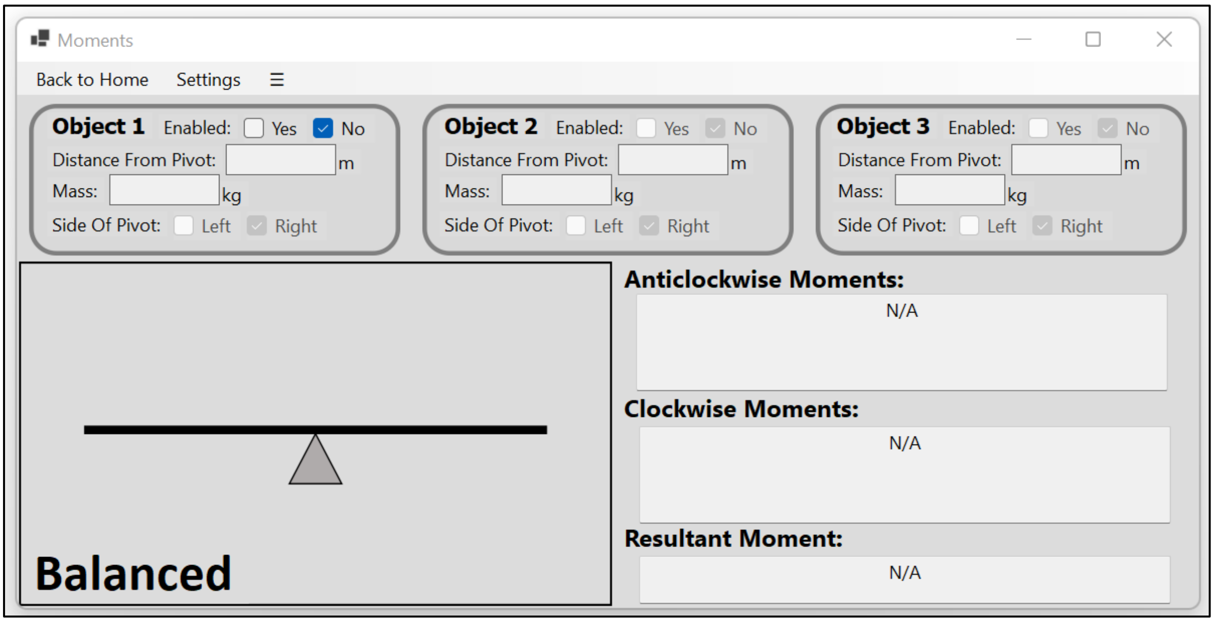






Moments Simulation

Video - https://youtu.be/RyVJUnTz3zw



This simulation has been designed with the intention of demonstrating the effects of adding up to three objects to a beam supported centrally by a pivot. It displays whether the system is balanced or not and the reasoning behind that conclusion by showing, to the right, the individual moments of all objects and the overall, resultant moment of the system.

- About

How To Use -

To effectively use this simulation, you must, one by one, chose whether you want to include the object within the system and if so, select the side of the pivot you wish the object to be on. Also, for useful results, you should add a 'mass' and 'perpendicular distance from the pivot' for each object you wish to use within the two textboxes. (If you find it difficult typing these results in because a '0' is behind your value you can either, 1. Type after the '0' within the textboxes, 2. Highlight the '0' and type to replace it.)

Moment Equation:

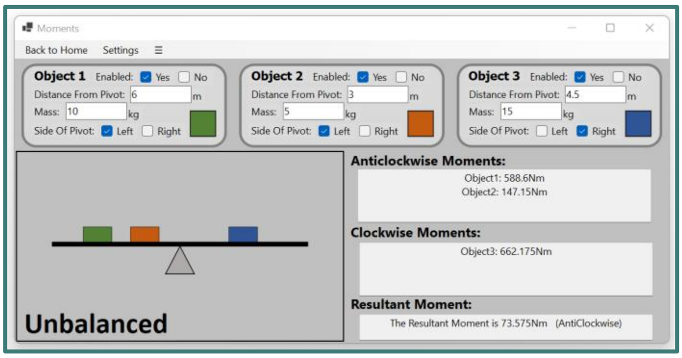
moment = F * d

Where:

F = force (weight of the object)

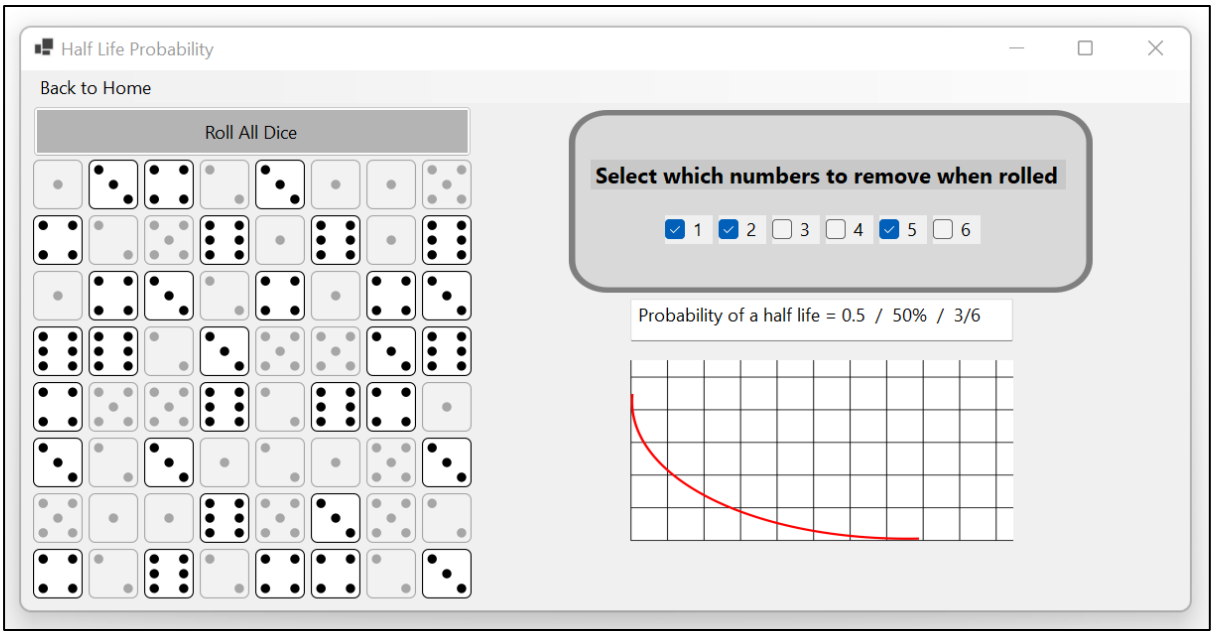
d = perpendicular distance from pivot

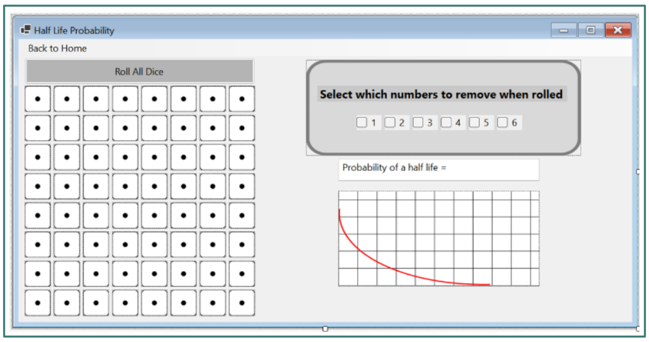
- Equation Used



Half Life Probability Simulation

(NOT PART OF THE FINAL PROGRAM)



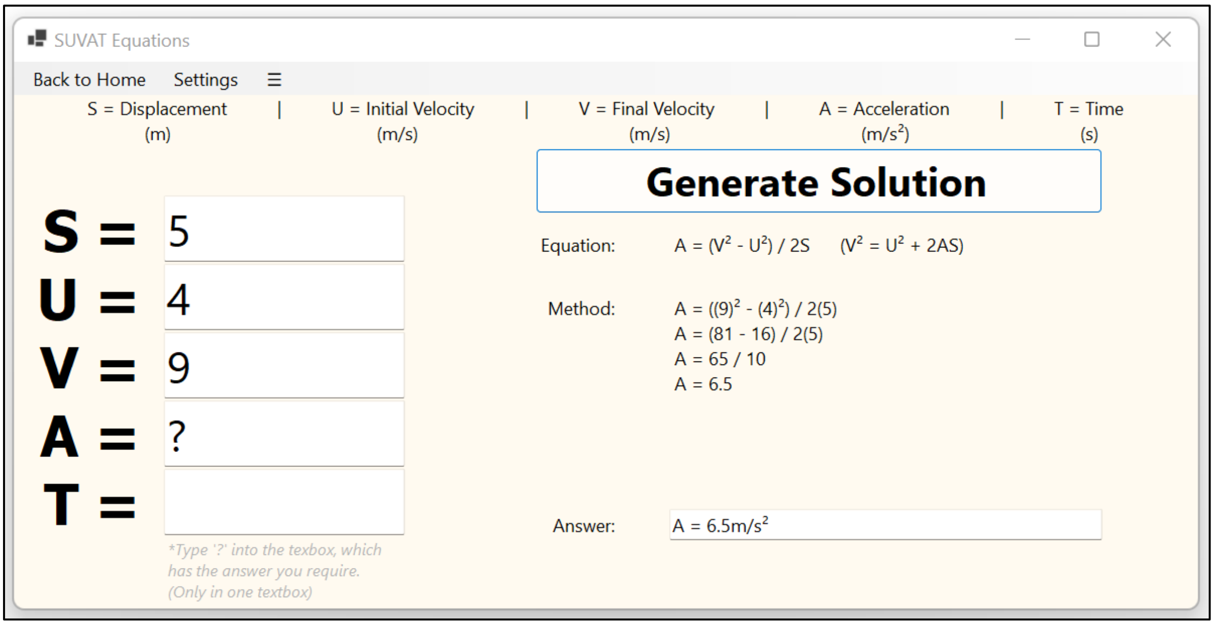


Why didn't I include this simulation in my final program?

The 'Half Life Probability' Simulation was the fifth simulation that I began work on yet there were issues that resulted in it not being a part of the final program. There were two main reasons that contributed to me finally deciding to remove this simulation from the program. The first being that, using only visual studio, creating a graph that would display an exponential curve, custom to the user's inputs, wasn't possible and I didn't want the users' customisation to be reduced. The second was that for the program to spin the dice individually and randomly, depending on the inputs from the user, I had to use a 'timer' however this was too slow and made the simulation uninteresting very quickly, on top of the lack of functioning graph. With these to points considered I removed the simulation from the program and started work on the simulation that was designed sixth.

SUVAT Solver Simulation

Video - https://youtu.be/N-eu4X0Z1dw



This simulation has been designed to calculate and solve a SUVAT problem, using the SUVAT equations, and then displaying how the calculations were made

- About

How To Use -

To effectively use this simulation, you must fill a minimum of 3 textboxes with values corresponding to the letter. Also you need to type a '?' in the textbox where you require an answer. Then, if all values have been inputted correctly, when 'Generate Solution' is pressed, the Equation, Method and Answer will all be displayed.

SUVAT Equations:

$V = U + AT$

$V^2 = U^2 + 2AS$

$S = UT + \frac{1}{2}AT^2$

$S = VT - \frac{1}{2}AT^2$

$S = \frac{1}{2}(U + V)T$

Where:

S = displacement

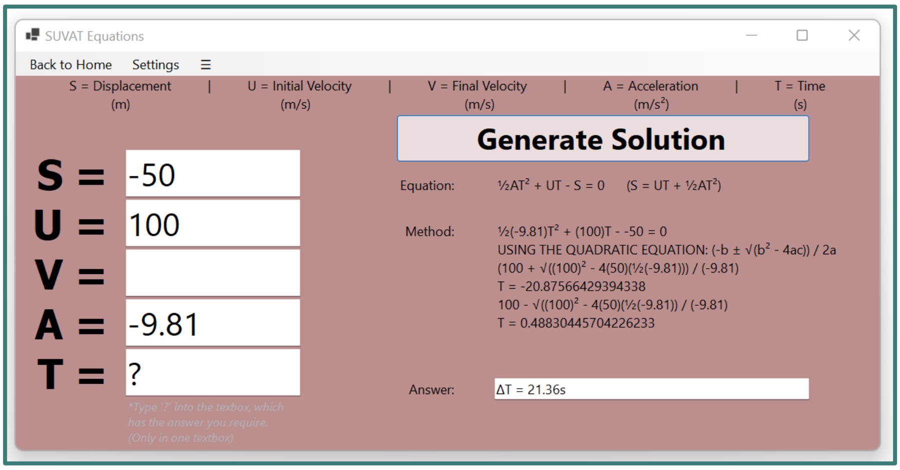
U = initial velocity

V = final velocity

A = acceleration

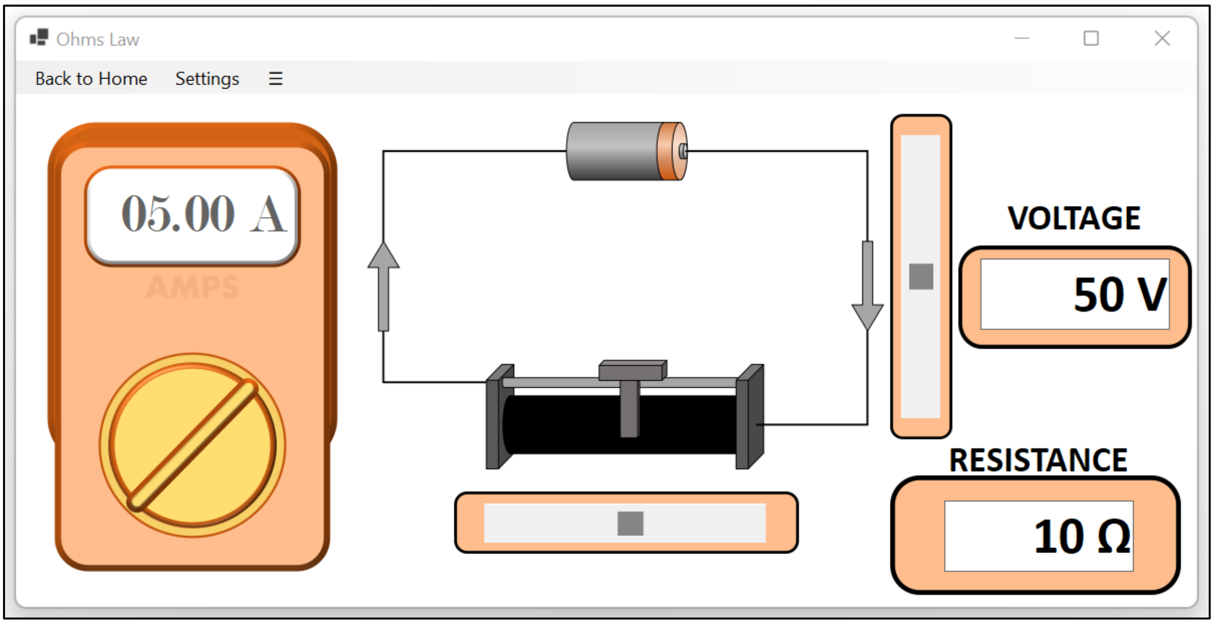
T = time

- Equations Used



Ohm’s Law Simulation

Video - https://youtu.be/lYZbI5-gCQs



This simulation has been designed to show ‘Ohm’s Law’ in action by allowing the user to change values of Voltage and Resistance to change the value of Current displayed to the left

- About

How To Use -

To effectively use this simulation, you can, simply, slide the two sliders within the simulation. One of them changes the value of voltage and the other changes the value of resistance. They are then used to calculate and display the current

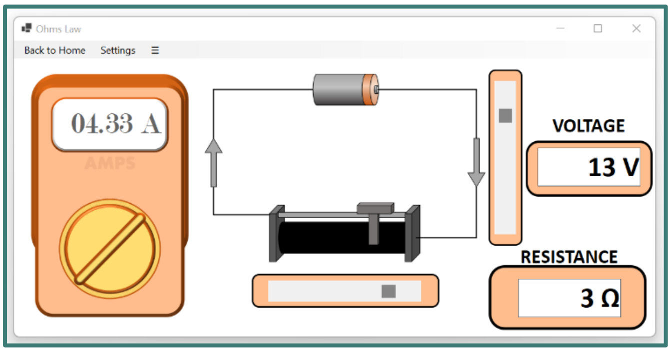
List of Equipment:
Battery: To provide a voltage to the circuit.
Variable Resistor: To change the resistance within the circuit.

- Equipment Used

Equation Used -

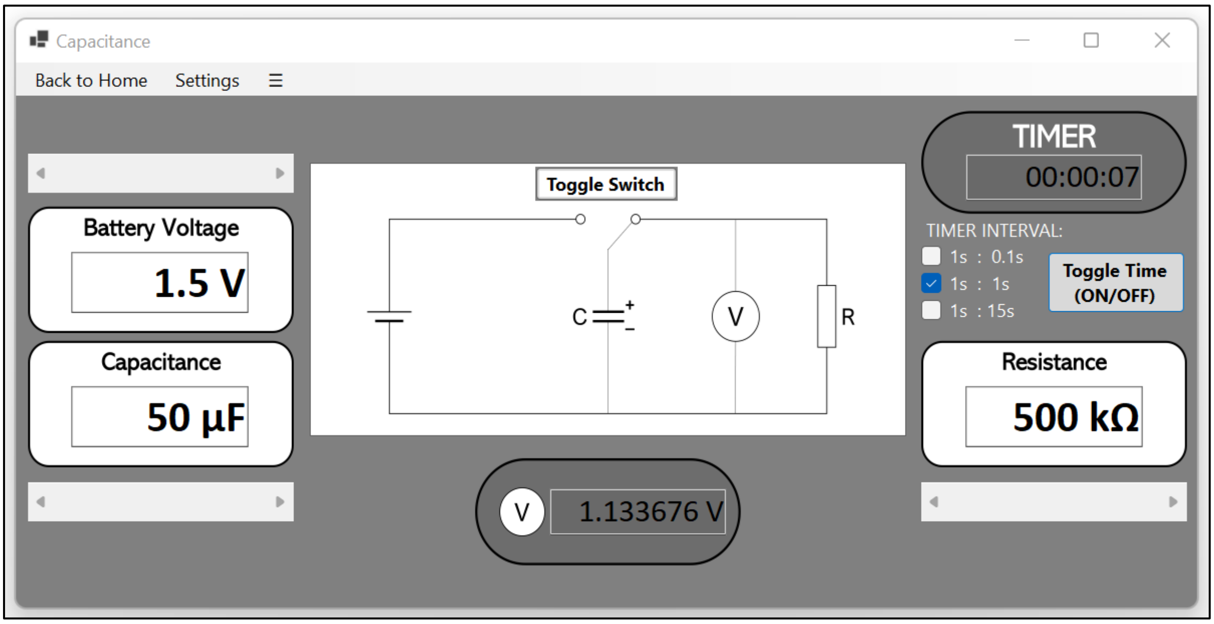
Ohm's Law Equation:
V = I * R

Where:
V = voltage
I = current
R = resistance



Capacitance Simulation

Video - https://youtu.be/yDUwlc0KbMk



- About

This simulation has been designed to show a discharging capacitor in action, live, by also including a timer and changing the value of voltage according to the interval of the timer, set by the user.

How To Use -

To effectively use this simulation, you must slide the three sliders according to the values you wish to input for Capacitance, Battery Voltage and Resistance. Then toggle the switch and watch the voltmeter reading decrease with time. Also you can slow down or speed up the simulation by changing the timer interval to one of three options or by pausing the timer by pressing the allocated button

List of Equipment:
Battery: To provide a voltage to the circuit.
Resistor: To provide the circuit with a resistance.
Switch: To change the path of current through the circuit.
Capacitor: To store electrical energy within the ciruit and then discharge.
Voltmeter: To record the voltage left within the circuit due to the discharging of the capacitor.
Stopwatch: To keep track of time during the experiment.

- Equipment Used

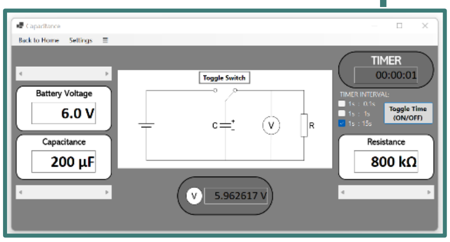
Equation Used -

Discharging Capacitor Equation:

$V = V_0 * (e \wedge ((-1) * (t / (R * C))))$

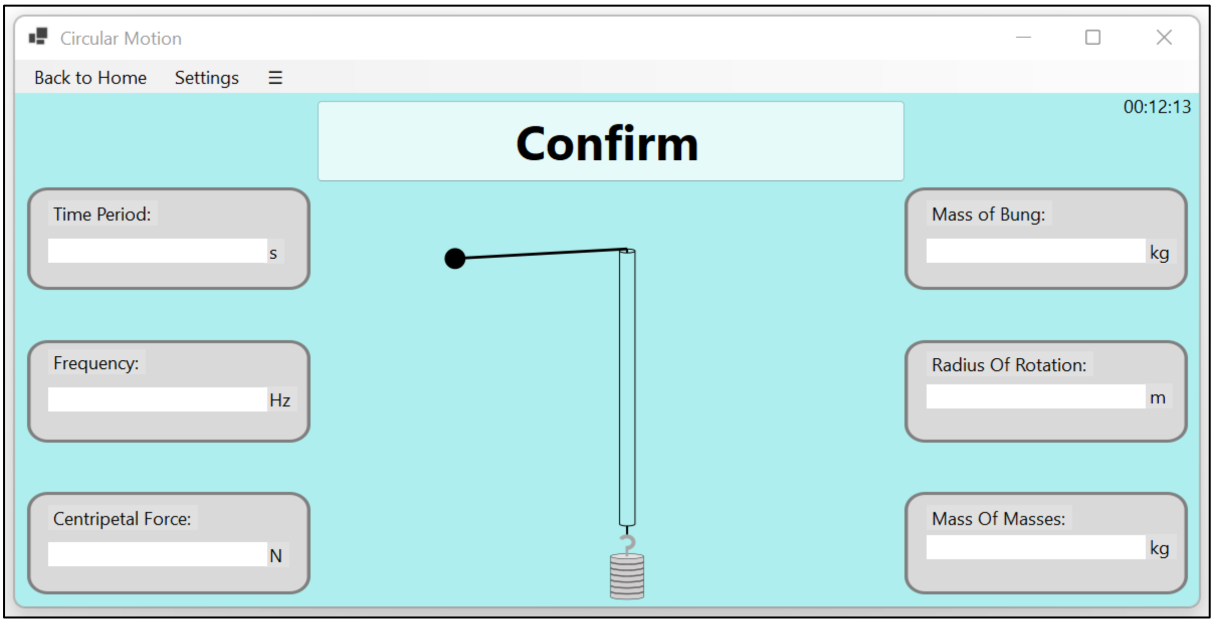
Where:

V = voltage
V_0 = initial voltage
e = Euler's Number
t = time
R = resistance
C = capacitance



Circular Motion Simulation

Video - https://youtu.be/aN6arlSkpM4



This simulation has been designed to display circular motion by replicating a practical which involves a bung being horisontally swung around a pipe via a string with masses attached to the end

- About

How To Use -

To effectively use this simulation, you must input values into the corresponding textboxes (taking into account the size of the units) and type a '?' into the textbox where you require an answer. If it is possible, the simulation with then calculate this required answer.

Force Equations:

$F = ma$

$F = m * 4 * \pi^2 * f^2 * r$

$F = (m * 4 * \pi^2 * r) / T^2$

Where:

F = force

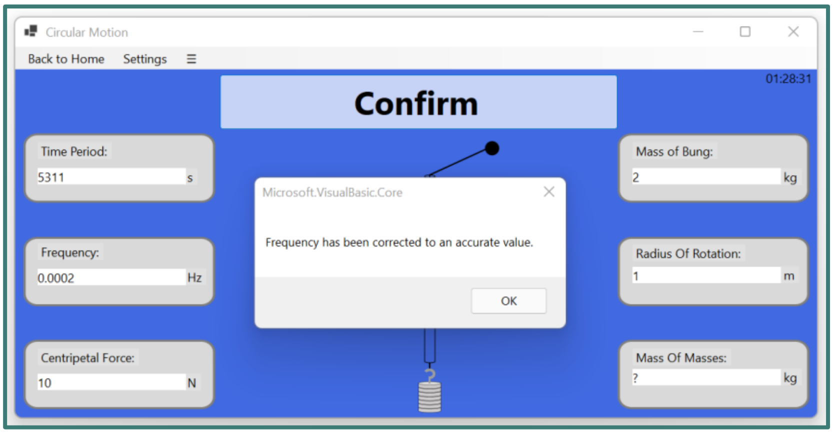
m = mass

f = frequency

T = time period

r = radius of rotation

- Equation Used



What changes were made to the 'Opening Animation'?

The ideas that were used in the initial design of the 'Opening Animation' have remained consistent being that the words 'Physics Simulations' are built up using different physics theories. The elements that remain the same are that of the letters 'y' and 'c' are interacting and displaying magnetism yet the projectile motion representation using the tittle of the letter 'i' is no longer being used since both words are now displayed in all capitals and so the pistons now push the letter 'p' and both 's' letters in the word 'Physics'. Also 'h' and 'i' now rotate into place as I didn't feel there was much rotation in the initial design which made it feel somewhat flat as an animation.

What changes were made to the 'Home Page'?

Because one of the simulations that was in the initial design did not end up in the final program being the 'Half Life Probability' simulation, this meant that the number of buttons in the design was reduced by one, yet the layout did remain the same with the title of the program located at the top in the centre. The main difference between the design and the final outcome was that initially the buttons had no design yet in the final result, I decided to include personalised illustrations of each simulation to make the design feel more in accordance with the rest of the program and look more professional.

Simulation changes from Design to Result

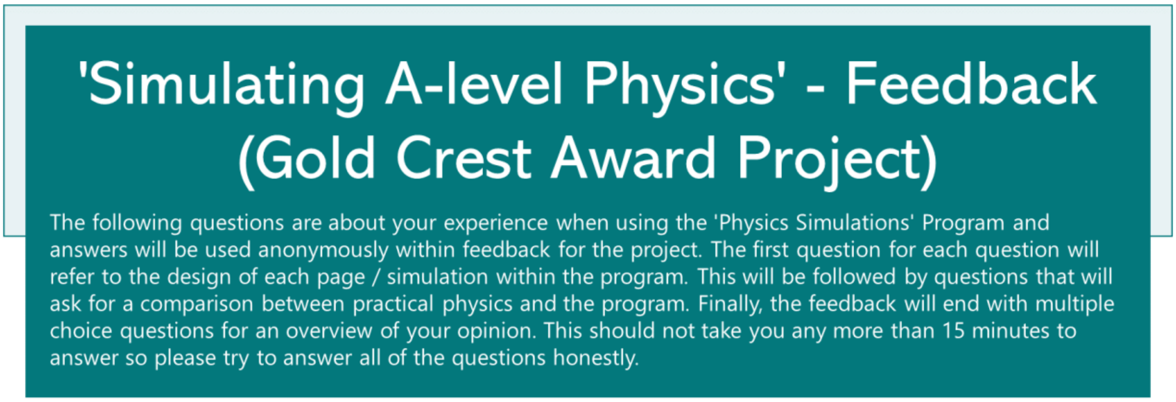
Simulation	Visual/Interface Changes	Functional Changes
Stationary Waves	The animation/system is now central to the display with the textboxes surrounding them. The 'Confirm' and 'Clear' buttons are now in the centre of the display at the bottom making the display more symmetrical and pleasing to the eye. The textboxes all have their own border to frame them meaning they are now more visually pleasing. The default background colour is now 'Floral White' rather than white making the simulation look better. There is also now a menu to the top of the design with the 'Home' button being a part of that. There is also a timer that is now displayed in the top right of the display. 'Nodes' and 'Antinodes' are now represented when there is a harmonic present.	The student now can access the settings where they can end the program. From 'More Details' in the 'Display Settings' the user can toggle the 'Nodes' and 'Antinodes' on and off. There is a way now to change the speed of the animation from 'Motion Settings'. The user now how the ability, with the addition of the timer, to 'Start', 'Stop' and 'Restart' it. The Number of Harmonics can now change from 1, broadening the range of uses for this simulation. The student can also now view 'About…', 'How To Use', 'Equipment Used' and 'Equation Used' which provide more detail for the student making the simulation more user-friendly
Momentum	The way a collision is being represented has changed from a potential of using 'dodgems' to using a snooker setup because dodgems rarely collide directly with each other and it is normally at an angle, whereas snooker balls often collide directly with one another. Another reason for this change was that the new design has a moving object colliding with a stationary object which dodgems don't represent. Due to this, colours have been changed to a background of 'Dark Green' to be more appropriate for the new design and mimicking a snooker table colour. Sliders are also used now instead of textboxes.	Now 'input boxes' are used to select final inputs. There is also now a menu at the top of the page where the student now can access the settings to end the program if they wish. Form the menu, the student also has the ability to view 'About…', 'How To Use' and 'Equations Used' which provide more information to the student if they require it.

The Result

Projectile Motion	In the final outcome of this simulation the angle is visible from a horizontal normal. And when the object is projected vertically upwards the 'degree of curvature' curve changes to a 'set square' to represent the 90 degrees. The 'Generate Result' button is no longer necessary because the student is given the option of projecting the object from 10 different surfaces, affecting the display and colours alongside the values displayed.	The user is now presented with the menu to the top of the display which allows the user to end the program via the 'Settings' or read 'About..', 'How To Use' or 'Equations Used'. Sliders are now used to change the velocity and angle instead of textboxes in the original design.
Moments	By default, the display is much less colourful than a version of the original design was, yet there is a way to change the background colour in 'Display Settings'. The system is slightly smaller and now displayed in the bottom left instead of the centre to make room for the information that is now displayed more prominently from the system.	If the student wishes to know more about the program, they can do by viewing 'About…', 'How To Use' or 'Equation Used'. They can also send the program from the settings. There is also now an increase in the number of objects that the user can now add to the system, from one to three, making the range of different possibilities for the system much greater.
SUVAT Solver	N/A – Almost identical other than the difference in background colour and the ability to change that within the 'Display Settings'.	The student now can read more about the functionality of the simulation, they can exit the program and go back to the 'home page' from the menu located at the top of the display. The equation and method is now displayed with the answer to help the student even more so they can replicate the same calculations.
Ohm's Law	The display is much cleaner and colourful and the simulation now uses a circuit that the student can interact with.	The student now can read more about the functionality of the simulation, they can exit the program and go back to the 'home page' from the menu located at the top of the display. The voltage and resistance can be toggled on and off from being displayed on the circuit from the settings. The student can no longer change the current value
Capacitance	This simulation is less colourful than the design and is now predominantly grey as to not distract from the contents of the simulation. There is also now a timer on display as there would be in person using a stopwatch.	The student now can read more about the functionality of the simulation, they can exit the program and go back to the 'home page' from the menu located at the top of the display. Sliders are now used instead of textboxes and there is an ability to change the speed of the timer
Circular Motion	The 'Confirm' button is now present on the simulation display to allow the students to confirm their inputs. The design is much more colourful and can be customized by the student in 'Display Settings'. The display of the masses in the system are much more realistic than were in the original design. There is now a timer displayed in the top right of the display.	The student now can read more about the functionality of the simulation, they can exit the program and go back to the 'home page' from the menu located at the top of the display. The student now how the ability, with the addition of the timer, to 'Start', 'Stop' and 'Restart' it. There is a way now to change the speed of the animation from 'Motion Settings'.

Feedback

I have used ‘Microsoft Forms’ to create this survey containing 22 questions for A-level students to answer as feedback so I can understand what student’s think of my designed and created, simulations and the program.


'Simulating A-level Physics' - Feedback (Gold Crest Award Project)

The following questions are about your experience when using the 'Physics Simulations' Program and answers will be used anonymously within feedback for the project. The first question for each question will refer to the design of each page / simulation within the program. This will be followed by questions that will ask for a comparison between practical physics and the program. Finally, the feedback will end with multiple choice questions for an overview of your opinion. This should not take you any more than 15 minutes to answer so please try to answer all of the questions honestly.

Total Questions – 22

Open-ended Questions – 19

Multiple Choice Questions – 3

What is the general purpose of the feedback form?

The general purpose of the feedback form is to gather an overview of what A-level students think of my program containing 8 simulations and to state, if they have any, improvements to include in possible extensions to the program. This will assist me when deciding whether or not this project/program was successful in completing a program that contains simulations to help students with revision and the understanding of different theories from a visual format. I also hope to find trends in the data gathered from multiple choice questions which could display common likes/dislikes to determine which elements of the feedback and improvements are more important to the average user that tested the program.

1

When using the program, what were your opinions on the design of the 'Opening Animation' and what improvements would you suggest?

The above question makes reference to the opening animation which has been displayed on page 32

What is the purpose of this question being asked?

This question has been written to determine whether the opening animation was a viable addition to the program. I started with this question because it is the first thing the user views when they run the program and sets the theme for the program which is repeated within the home page.

What is the expected result of the feedback for this question?

I expect the result of the feedback for this question to be positive. Users may suggest, as a possible improvement, a smoother animation which could be achieved with more time invested into the animation or a wider range of colours because currently, a few are used. Yet generally, I do believe that it's an appropriate component to the program and although it isn't a simulation or doesn't have a practical use, it enhances the user experience before hand.

2

When using the program, what were your opinions on the design of the 'Home Page' and what improvements would you suggest?

The above question makes reference to the home page which has been displayed on page 33

What is the purpose of this question being asked?

The purpose of this question is to grasp the average opinion on the design of the home page. I think this is important as, it's the first page that the user can interact with in the program. The design of a homepage creates the first impression and, in this program, each button which redirects the user to the simulations, has a corresponding illustration displayed, to entice the user into running a simulation.

What is the expected result of the feedback for this question?

My view on the likely results for this feedback are that most will like the colourful illustrations of all 8 simulations as, I think they are an accurate representation of each simulation. Having said this, I think that a possible comment that could be made may be that there is too much 'white space' within the page and that the buttons could be larger which is an improvement that I would agree with and could be applied to the program as a simple fix.

3

When using the program, what were your opinions on the design of the 'Stationary Waves' simulation and what improvements would you suggest?

The above question makes reference to the stationary waves simulation which has been displayed on page 34

What is the purpose of this question being asked?

The reason for this question being asked is because the practical that this simulation is represented is a very visual practical as, you must view the harmonics for the practical to work and the calculations to be accurate. Also, for this simulation, I chose to, by default, have a diluted colour for the background. This was a conscious decision as to not distract from the animation in the foreground.

What is the expected result of the feedback for this question?

Users may not like the fact that the default colour for the background is weak, and doesn't stand out, so I think that it will be an improvement that is suggested in the feedback yet, I wouldn't change it as I believe in the choice and have given the user the ability to easily change the colour from within the 'Colour Settings', where they have a wide variety of colours that range from vibrant to more mild colours.

4

This simulation was based off 'Required Practical 1' (Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string). Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the stationary waves simulation which has been displayed on page 34

What is the purpose of this question being asked?

The stationary waves simulation involves many components being the: tension in the string; properties of the string; length of the string; frequency of vibrations and the number of harmonics displayed. All these components make the practical slightly more in depth than some others which is a strong reason to have the physics be accurate and this question should receive an average view on the execution.

What is the expected result of the feedback for this question?

I expect the comments for this question to be positive as the diagram displaying the physics is almost identical to the practical apparatus setup and the inputs are very clearly displayed in my opinion for the user to input their chosen values into.

5

When using the program, what were your opinions on the design of the 'Momentum' simulation and what improvements would you suggest?

The above question makes reference to the momentum simulation which has been displayed on page 35

What is the purpose of this question being asked?

The momentum simulation is the only simulation where objects are interacting with one another and is based off another very visual practical, therefore the visual design of this simulation is important and must be appealing to the eye. This question has been made to understand whether users feel like it is or not.

What is the expected result of the feedback for this question?

I think that the feedback for this question will be mostly positive apart from one obvious enhancement to the program which is to include most types of collisions. More types could include: a range in inelastic percentage for the collision, inputted by the user; a way to include more than two objects, a way to vary the angle of momentum on a 2d plane and an addition of more objects than can also move when the animation starts as opposed to only one. These are all theoretically possible with more time.

6

This simulation was based off the theory of momentum and inelastic collision. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the momentum simulation which has been displayed on page 35

What is the purpose of this question being asked?

To add possible extensions to this simulation, it is useful to gather thoughts on the current status of the simulation and whether or not it is a good reflection of the physical counterpart of which the simulation is based upon. This is important as, if it isn't, then it isn't useful deeming the simulation impractical to use because it doesn't accurately represent what the user expects it to.

What is the expected result of the feedback for this question?

I expect the feedback for this question to be both positive and include improvements that could be made. I think the fact that sliders are used to change the contents of the textboxes, and in turn, the values used in the questions, may be considered to be an issue by some users as they cannot enter specific values of their choice. Yet I do think that simulation in it's current state is executed well and so doubt any major negatives will be mentioned in feedback.

7

When using the program, what were your opinions on the design of the 'Projectile Motion' simulation and what improvements would you suggest?

The above question makes reference to the projectile motion simulation which has been displayed on page 36

What is the purpose of this question being asked?

The approach that I have taken with this simulation, being that I have allowed the user to decided the surface of which they wish to project their object from means that the display of each surface is important as it must look visually appealing to the eye. This question is therefore important to grasp whether the users approve of the design as, if they don't, changes would need to be made.

What is the expected result of the feedback for this question?

I presume the results for this question will be varied as the display can change many times because the user has the option to select from 10 different 'surfaces' which changes the colour and sometimes format of the display. I expect the fact that when the 'Earth' background is displayed the ground is flat unlike the other planets to be a comment made in a negative light which could be a future improvement made to the program with more time.

8

This simulation was based off the theory of projectiles. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the projectile motion simulation which has been displayed on page 36

What is the purpose of this question being asked?

The purpose of this question being asked is to gather the feelings of the users that have tested this simulation towards how accurate they believe the practical physics was represented in the projectile motion simulation in order to make changes if the majority suggests them and the improvements are possible to achieve.

What is the expected result of the feedback for this question?

I expect a possible extension to the simulation being that of being able to input our own values of velocity, specific angles and gravitational acceleration as opposed to sliders. Also, a way to change the height at which the object lands compared to the starting height could be useful or an introduction of air resistance to make the calculations more realistic perhaps. All these extensions are possible, they will just require time to include within the simulation if the user deems it to be necessary.

9

When using the program, what were your opinions on the design of the 'Moments' simulation and what improvements would you suggest?

The above question makes reference to the moments simulation which has been displayed on page 37

What is the purpose of this question being asked?

This question is especially important as there are many components to the page design and there are many possible visual outcomes for the form to show in terms of where the objects are located within the system display. Often it is the case where too much information on a page can be unappealing to the eye, so it is important to gather user feedback to prevent this from being the case.

What is the expected result of the feedback for this question?

I think that, overall, the feedback for this simulation will be positive as I spent a lot of time making sure that the layout of this simulation was right after the initial design phase, as I considered it to be very important. I do think, however, a few users may suggest a way to include more objects in the system or change the default colour for the background as grey can be viewed as being unappealing.

10

This simulation was based off the theory of moments. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the moments simulation which has been displayed on page 37

What is the purpose of this question being asked?

The purpose of this question being asked to the users who tested the simulation is to collate the general thoughts of the users when it comes to the physics involved with the moments simulation when compared to the practical physics.

What is the expected result of the feedback for this question?

I expect feedback for this question to be very brief as only one, very simple to use, equation has been used. I think that the page was overall executed very well yet a possible improvement that may be suggested in feedback could be that, in reality, a beam will not be uniform, so a user may want the ability to decide the position of the centre of mass which will influence whether the moment is balanced and could change the direction and magnitude of the resultant moment.

11

When using the program, what were your opinions on the design of the 'SUVAT Solver' simulation and what improvements would you suggest?

The above question makes reference to the SUVAT solver simulation which has been displayed on page 39

What is the purpose of this question being asked?

The purpose for this question is to gather users' opinions on the design of the SUVAT solver simulation. There are not many components to this simulation, and it is very text/equation based, as apposed to others which are heavily visual. This means that the visual design is even more important as to engage the user into staying on the program.

What is the expected result of the feedback for this question?

I expect the result of this question to be very neutral as the design isn't extremely visually appealing, but I don't believe it has to be.

12

This simulation was based off the SUVAT equations. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the SUVAT solver simulation which has been displayed on page 39

What is the purpose of this question being asked?

The reason that I included this question within the feedback from is because SUVAT equations are used for many different types of questions/scenarios during the mechanics topic meaning there are many parts of this simulation that must echo the practical physics and perform the correct calculations. Another part of this simulation is to display the method of the working out which must be correct also.

What is the expected result of the feedback for this question?

I think that the feedback for this question will be very positive because it solves a major problem which is the amount of time that some mechanics questions take, whereas this simulation cannot only solve the equations, but it can show the user how to re-arrange a chosen SUVAT equation and then how to use it, with a step-by-step method displayed with many decimal places.

13

When using the program, what were your opinions on the design of the 'Ohm's Law' simulation and what improvements would you suggest?

The above question makes reference to the ohm's law simulation which has been displayed on page 40

What is the purpose of this question being asked?

The reasoning behind writing this question is to conclude the views of the users on the design of the ohms law simulation display. This simulation is very simple, there are only two variables that the user can change: the voltage and the resistance, using sliders, so it is important that the visual aspect of the simulation feels appealing for the user.

What is the expected result of the feedback for this question?

I expect there to be arguments for both sies in the feedback for this question, both positive and negative. I think some users will suggest that the form may feel slightly empty, yet I do think that the design of the circuit and how it moves when the user interacts with the slider, only enhances the user experience when using the simulation.

14

This simulation was based off 'Ohms Law'. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the ohm's law simulation which has been displayed on page 40

What is the purpose of this question being asked?

The purpose of this question being asked its to understand the users' opinions of the functionality of the simulation and whether they think that it is an accurate representation of the physics involved with the corresponding practical.

What is the expected result of the feedback for this question?

I expect, overall, the feedback to be fairly positive for this question because I think the functionality of the simulation works well and the calculations performed in the background are fast and accurate, yet I do think that there will be comments on the lack of customization from a user's point of view which could be an addition as a future enhancement to the program if more changes were to be made.

15

When using the program, what were your opinions on the design of the 'Capacitance' simulation and what improvements would you suggest?

The above question makes reference to the capacitance simulation which has been displayed on page 41

What is the purpose of this question being asked?

The purpose of this question is to understand the opinions of the users when it comes to the design of this simulation. There are many components to this simulation and, due to this, it isn't as simple to use immediately meaning the design is very important because it must be as clear as possible as to make the simulation easy to use for a student.

What is the expected result of the feedback for this question?

I think that the feedback for this question will be, mostly positive as, I believe the outcome of it was well executed and laid out.

16

This simulation was based off 'Required Practical 9', (Investigation of the charge and discharge of capacitors). Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the capacitance simulation which has been displayed on page 41

What is the purpose of this question being asked?

The purpose of this question as a part of the feedback form is to gather the views of users, specifically their opinion on whether they think that the simulation was an accurate representation of the physics involved with the practical which the simulation is based upon. There are multiple elements of the simulation that the user can change as to reflect the practical, these must all be well executed.

What is the expected result of the feedback for this question?

The feedback for this question that I expect includes positive comments about the timer and how the speed of it can be changed. I also think that comments will be made on the circuit and how it is reflective of the required practical. Yet it may be commented on, that the simulation doesn't include the charging of a capacitor and I think, that could be a great extension to the program with more time.

17

When using the program, what were your opinions on the design of the 'Circular Motion' simulation and what improvements would you suggest?

The above question makes reference to the circular motion simulation which has been displayed on page 42

What is the purpose of this question being asked?

With the design of the circular motion simulation display, I decided to take a simple approach and only have the one moving animation in the centre of the form design. Due to this, I presume the opinions on the design will be varied, so this question is to determine whether or not the users that tested this simulation, like the design of the simulation, and if not, a reason for that.

What is the expected result of the feedback for this question?

As stated, I believe the feedback for this question will be varied due to the simplistic approach of this simulation. I think one specific improvement that will be mentioned in the feedback will be the lack of the ability for the user to change the colour of the system as, they can only change the background colour. This is a simple addition to the program and could be achieved with more time as a possible extension to the program.

18

This simulation was based off 'Circular Motion'. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

The above question makes reference to the circular motion simulation which has been displayed on page 42

What is the purpose of this question being asked?

The circular motion practical, which this simulation is based up off, has many components and 3 different equations are used within the calculations of the simulation. Due to this, the functionality of this simulation is very important and must be an accurate representation of the physics involved with the practical.

What is the expected result of the feedback for this question?

I expect the result of the feedback for this question to be positive as I have tested the ability of the equations in this practical and have come back with no failed tests.

19 What is your concluding opinion of the program?

What is the purpose of this question being asked?

This question is a very open-ended question and refers to all components of the program: the opening animation; the home page and all eight of the simulations. This question is especially important because it summarises the opinions of the users who tested the program and, as a result, will conclude whether or not the average user likes the program.

20

Please fill in the following table of how useful you found each simulation:

	Useless	Not Useful	Somewhat Not Useful	Somewhat Useful	Useful	Very Useful
Stationary Waves	○	○	○	○	○	○
Momentum	○	○	○	○	○	○
Projectile Motion	○	○	○	○	○	○
Moments	○	○	○	○	○	○
SUVAT Solver	○	○	○	○	○	○
Ohm's Law	○	○	○	○	○	○
Capacitance	○	○	○	○	○	○
Circular Motion	○	○	○	○	○	○

What is the purpose of this question being asked?

The purpose of this question is to gather an overall opinion of students on the usefulness of all eight simulations. This is important as, if the simulations are not useful for students to use, then the project couldn't be considered to be a success as the initial problem isn't solved.

What is the expected result of the feedback for this question?

I expect the result of this feedback to be very positive because I based my simulations off of answers to a survey answered by 34 students, so I predict every simulation will be considered to be useful from every student.

21

How likely are you to use this simulation in future?

0	1	2	3	4	5	6	7	8	9	10

Not at all likely Extremely likely

What is the purpose of this question being asked?

This question is a way to simply understand whether the average student is likely to use the simulation in future. This is important as, the purpose of this program being created, was for students to use it in future.

What is the expected result of the feedback for this question?

I expect the result of the result for this to be no less than a rating of 6.

22

Overall, how would you rate your experience using the program?

☆ ☆ ☆ ☆ ☆

What is the purpose of this question being asked?

This question is another way to simple understand the average opinion of the program from every student who tests it.

What is the expected result of the feedback for this question?

I expect the result of the result for this to be either 4 or 5 stars.

Feedback

1

User Feedback

When using the program, what were your opinions on the design of the 'Opening Animation' and what improvements would you suggest?

Perhaps make the animation show on the same form as the menu.

Sleek and well designed, however it could've incorporated more physics sections in making the title

I like the way that the name built itself using different physics ideas but could be improved by making the animation smoother.

2

User Feedback

When using the program, what were your opinions on the design of the 'Home Page' and what improvements would you suggest?

An indicator to shoe that a part of the program is loading up.

Very convenient and nice to look at, maybe an improvement could be to use up some of the empty space

I thought that the home page was well presented and the images for each simulation displayed a glimpse of what the simulation was when you enter it. I would say that the capacitance simulation could be made a more vibrant image on the home page like the others because it doesnt really stand out from the background.

3

User Feedback

When using the program, what were your opinions on the design of the 'Stationary Waves' simulation and what improvements would you suggest?

Colour settings for text as well could be included. I like the level of customisation.

It was clear to use, and you can use settings to get more details if confused

I like the design of this simulation because the background colour is very neutral as to not distract from the simulation. Possibly could increase the font size of MassPerUnitLength because it is hard to read.

4

User Feedback

This simulation was based off 'Required Practical 1' (Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string.). Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

I believe this was an accurate representation of the practical, good job.

It was quite accurate, it is layed out the same, has the same variables/equipment and the amounts change similarly

I do think this simulation was an accurate representation of the physics involved with this practical.

5 User Feedback

When using the program, what were your opinions on the design of the 'Momentum' simulation and what improvements would you suggest?

I like the animation that visually displays the results.

It is easy to use and well animated, could potentially give different scenarios for collisions as an improvement

I like the design of this simulation because even though it its suggested anywhere, i know that it is based off of snooker balls, which is a realistic example that most people can relate to.

6 User Feedback

This simulation was based off the theory of momentum and inelastic collision. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

It is accurate, however precise values may be difficult to enter.

It seems to be an accurate representation of how the balls would move in a real life scenario

I do think this.

7 User Feedback

When using the program, what were your opinions on the design of the 'Projectile Motion' simulation and what improvements would you suggest?

The layout is slightly confusing with the results, perhaps the results box should be highlighted or display noticeable change.

It allows you to change the velocity, angle and planet which is quite useful and displays lots of information

I liked the design of this simulation because it is colourful and has multiple different opinions. However, I would say that for some options chosen the text on the right isn't as easy to see as when others are being displayed.

8 User Feedback

This simulation was based off the theory of projectiles. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

This simulation provides an accurate set of results, however an option to add custom gravity acceleration could be useful.

It seems quite accurate, such as how when the planets are changed it effects the height and time taken

I do because it didn't contain many parts and I have checked the calculations and they are very accurate.

9 User Feedback

When using the program, what were your opinions on the design of the 'Moments' simulation and what improvements would you suggest?

No complaints, it is visually appealing and easy to use.

It was easy to use, can change lots of useful information like distance and mass. Would be a good improvement to add different scenarios of moments

I think that the design of this simulation is very well laid out and there is no wasted space within the display. I also like the way that I am able to customise the display by changing the settings.

10 User Feedback

This simulation was based off the theory of moments. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

Being able to add another pivot, or move existing pivot would be nice, also the rod could be non-uniform. Other than that, it is an accurate representation.

I think it's quite an accurate representation due to how specific you can be with the distances and masses

I do think that this simulation was reflective of the physics involved with this practical.

11 User Feedback

When using the program, what were your opinions on the design of the 'SUVAT Solver' simulation and what improvements would you suggest?

Like how the method is shown, although an indication of the program calculating the solution would be welcome.

I think it would be useful for calculating Suvats and shows you the whole calculation to help you calculate it in future

I do like the design of this simulation and think that it is very visually appealing whilst also displaying all of the required information. I also like the fact that I can change the background colour from within the settings yet I think the default background colour is slightly bland.

12 User Feedback

This simulation was based off the SUVAT equations. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

Since it displays how to solve the equation, I believe it is an accurate representation. Answer also includes a lot of decimal places.

It seems to do accurate calculations of the suvats

I think that this simulation is, and I also like the usefulness which makes what would be a difficult calculation immediately visible to view as a method and answer.

13 User Feedback

When using the program, what were your opinions on the design of the 'Ohm's Law' simulation and what improvements would you suggest?

For displaying the Ohm's law practical, this is a nice program.

Easy to use and displays the necessary information, would be useful if you could type into the text boxes

I think that the colours could be improved in this simulation as there is a lot of the plain white background visible. but the circuit design and the ammeter are visually pleasing.

14

User Feedback

This simulation was based off 'Ohms Law'. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

Optional feature of changing resistor into a non-ohmic component would be good to show lack of proportionality.

It seems to follow the trend of ohms law quite realistically.

This simulation is very simple but very well executed and do think that it was an accurate representation of the physics involved with this practical.

15

User Feedback

When using the program, what were your opinions on the design of the 'Capacitance' simulation and what improvements would you suggest?

Great for showing capacitor discharge, perhaps an option to show capacitor charge as well?

Well designed, clear diagram and convenient to use

I do like the design of this simulation overall as, similarly to the moments simulation, there are many components to it, but they all have their own space within the design, and I think that it is visually appealing. One improvement could be to include, within the settings, a way to change the background colour (an ability that is available in some other simulations and could be a good addition here).

16

User Feedback

When using the program, what were your opinions on the design of the 'Capacitance' simulation and what improvements would you suggest?

Observing the program, it is displaying the exponential decrease relationship that would be visible when using the equations. I like the addition of the feature which slows the clock down so that readings can be read.

Very similar to how it would be done in reality and seems to use accurate numbers

This simulation is very accurate when compared to the practical physics.

17 User Feedback

When using the program, what were your opinions on the design of the 'Circular Motion' simulation and what improvements would you suggest?

Visually great, simple to use too.

Well made, can change all the necessary variable which is useful, and it displays the bung moving which is a nice visual representation

I think that the design of this simulation was maybe a little too basic as there is too much empty space in my opinion. However, I do like the animation of the circular motion and think it enhances the simulation.

18 User Feedback

This simulation was based off 'Circular Motion'. Do you think this simulation was an accurate representation of the physics involved with this practical? Why?

Considering the accuracy is about 2 decimal places, I think this is a good representation of the practical and physics involved.

It seems very close to the real thing if not more accurate as it would remove any human error with timers etc

I think that the physics required are well incorporated within this simulation. One improvement could be to change the rotational speed, depending on the frequency/time period, in the display.

19 User Feedback

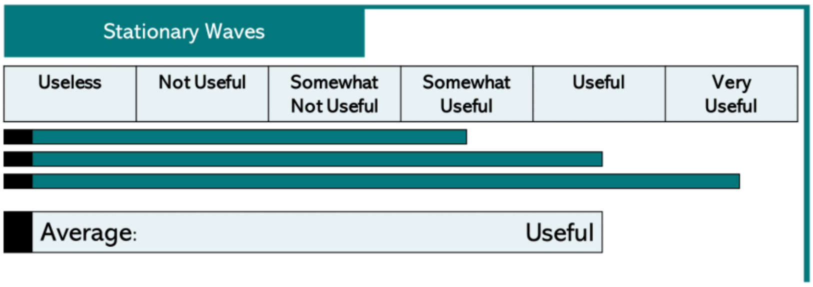
What is your concluding opinion of the program?

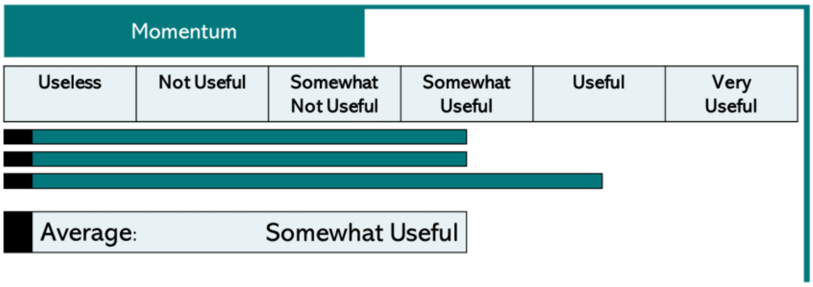
Easy to use and good visual design.

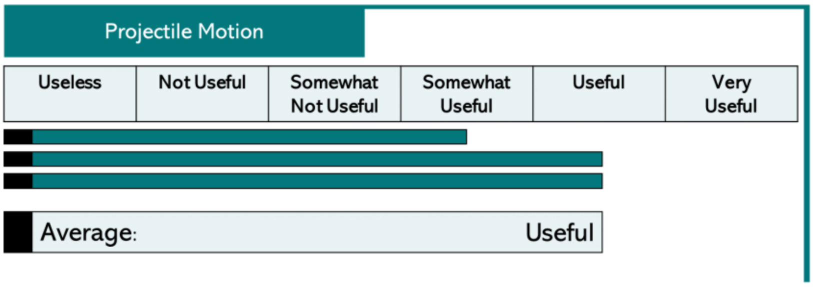
Overall, very useful, convenient and well displayed

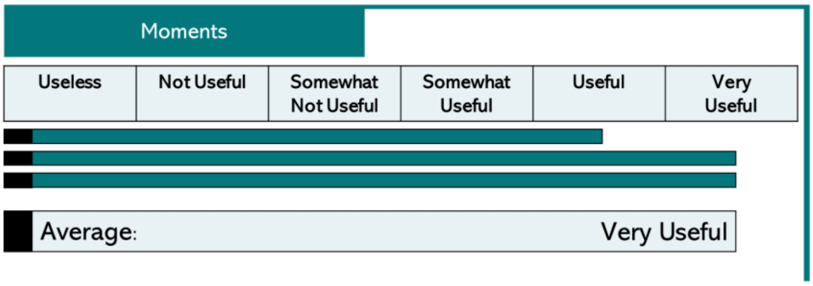
I really like the program and think that it will be very useful for many different scenarios. Overall, I think if I need to revise practicals or test my knowledge on SUVAT equations these are the most likely reasons for me using this program again.

20 User Feedback

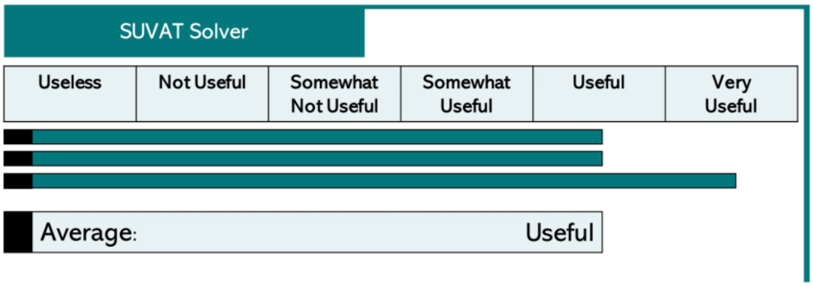


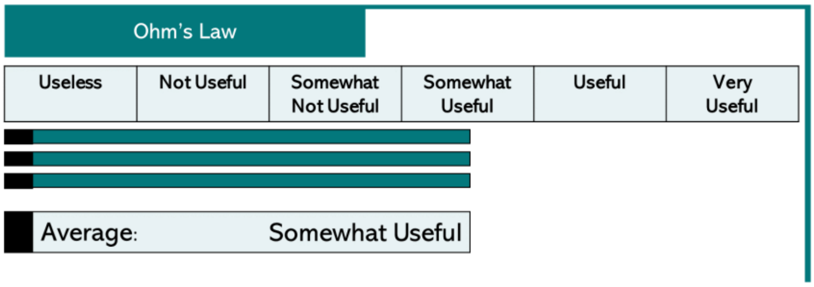


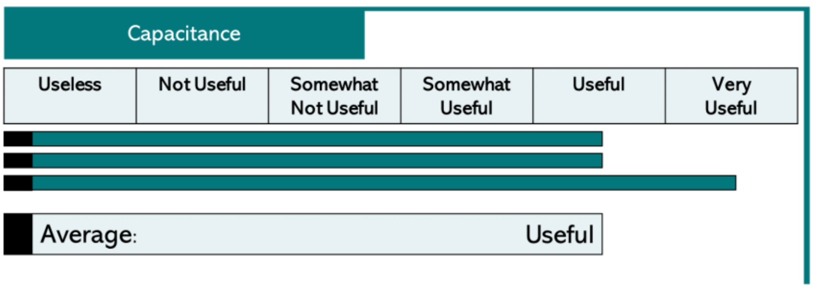


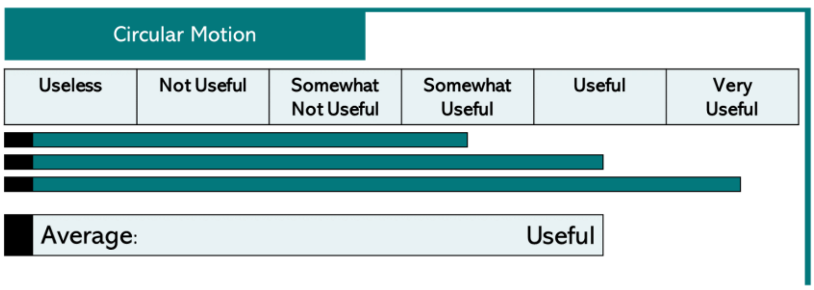


20 User Feedback

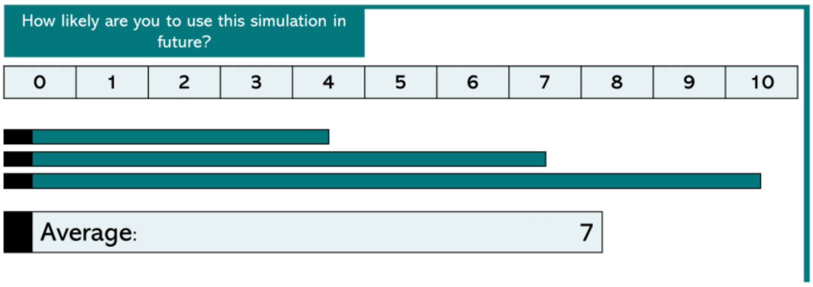




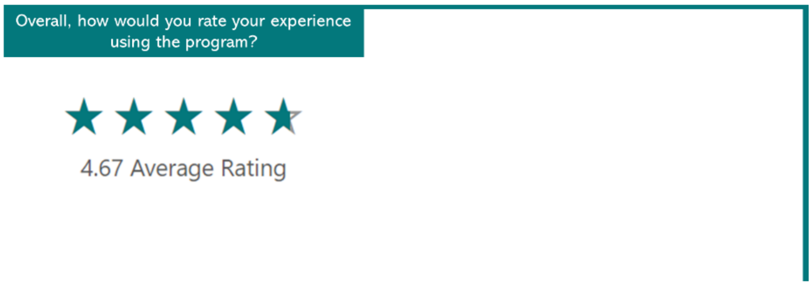




21 User Feedback



22 User Feedback



Overview of Feedback

Question:

1. As expected, the feedback for this question was mostly positive yet no user suggested that the amination could include more colour which implies they didn't think it did, however one student did suggest that the animation could be smoother which is an addition that could be made with more time, as I would have to create more individual frames in between the existing frames in the animation. Students did suggest though, that the animation could play on the 'Home Page' in front of the navigation buttons which I could include as a possible extension to the program to increase coherency between the 'Opening Animation' and the 'Home Page' and I could even make an effort for the end status of the animation to seamlessly fade into the title. with the same design, at the top of the 'Home Page'. It was also mentioned that there could be more physics sections in the making of the title in the animation which I could do by individualising each letter with their own aspect of A-level physics, e.g. the letter 'S' could bounce down as a string before slotting into place as a part of the title.
2. I expected the feedback for this question to be mostly positive due to the colourful design of the 'Home Page'. I did also predict that students may comment on the idea of too much 'white space' or the buttons being too small on the page, which was by one student, therefore, a solution is needed there, possibly by customizing the shapes of the buttons so that they are not rectangle and can wrap around the title for a more full, elegant final design. It was also suggested that a possible inclusion for the page could be to add an indicator when this part of the program is first loading up as, it can take several seconds to do so, and this would be possible by including an intermediate step between the display of the animation and the 'Home Page' showing a stationary 'loading' message. Another specific improvement that was suggested was to include a better design for the illustration of the 'Capacitance' simulation as, it was mentioned that 'it doesn't really stand out from the background' which, I agree, needs more colour to be more in keeping with the rest of the display.
3. Overall, the feedback for this question was positive yet, there were a few comments made for possible improvements. One suggested improvement was to include a new tb in the 'Colour Settings' which allows the student to change the colour of the text to add to the user interactivity and customization. Another contributed point was to increase the font size as some headers, such as 'MassPerUnitLength' can be 'hard to read'. This is an easy fix because there is room within the display for an increased front size and it shouldn't hinder the visual appeal of the design.
4. The comments made for this feedback question were all positive and not one of the three students that provided feedback found any fault with the functionality of the simulation, similarly to the results that I expected.
5. Generally, the feedback for this question was positive and no student had any complaints with the design of the 'Momentum' simulation.
6. The feedback given for the functionality of the 'Momentum' simulation was very constructive. One student stated that precise values may be difficult to answer, and this is due to the slider having such a small incremental value. This can be improved with the addition of a textbox instead of a slider, to allow the user to input their own values.
7. It was mentioned that the layout of this simulation was 'slightly confusing with the results' and as an improvement, 'the results box should be highlighted or display noticeable change'. This is an easy fix as an appropriate message box could be displayed when the contents changes. Another comment that was made was there could be a change in text colour for some display options as, some backgrounds almost match the colour of the text making it hard to read.
8. The feedback for the functionality of the 'Projectile Motion' simulation was very useful. A student stated that a good improvement to the program could be to allow the user to enter their own custom gravity acceleration value which could be simply added by either using an input box or a textbox to the right-hand side of the display.
9. The feedback for question 9 was very positive as one student said, 'no complaints, it is visually appealing and easy to use'. However, it was stated that there could be further additions of types of collisions, such as a moving object colliding with another moving object, this could be achieved with the use of the 2 images from the original design (the dodgems) and with time, could be a great new addition to the program.
10. Again, the feedback for this question was very positive, for the functionality of the 'Moments' simulation. It was mentioned though, that a good improvement could be to give the student the ability to change the location of the pivot in the system and change the location of the centre of mass. This would make the simulation more realistic as it would allow the rod to be non-uniform as it would most likely be if the practical was done in person. This would be an easy fix and would only require the addition of 2 variables.
11. A possible improvement that was suggested here was an indication of when the program is calculating. This would be an easy fix with the use of a message box and would, in my opinion, improve the user experience with the program. Another minor improvement that was suggested was to change the default colour as, it is slightly bland which is another easy fix with more time.
12. Overall, the feedback for this question was very positive and students liked the functionality of the 'SUVAT Solver' simulation and there were no improvements that were suggested by any student that tested the simulation.
13. The feedback for this question was very brief as, for the most part, the feedback was positive. It was suggested that textboxes could be used instead of sliders which would allow students to input their custom values which would, in turn, improve the user experience as a result of an easy fix. The other suggestion for a possible extension to the program was to decrease the amount of 'white space' in this design which I think could be easily implemented by increasing the text size for all the text and increasing the size of the circuit in the centre.
14. The feedback for the functionality of the 'Ohms Law' simulation, was overall, positive but does include possible suggestions for improvements that could be made. These include, one student stated that an 'optional feature of changing resistor into a non-ohmic component would be good to show lack of proportionality', which could easily be implemented will more time.
15. There were many comments made on the design of the 'Capacitance' simulation and most were positive yet there were some improvements suggested. One user said that charging a capacitor could be a good addition to the program too and this could be done with the same method just in reverse, meaning this is an easy addition to add to the program. The other improvement that was suggested was to include, like there is with other simulations, a way to change the background colour, to remain more consistent, and provide the user with visual options and interaction. This is also an easy fix to be added to the settings.
16. The functionality of the 'Capacitance' simulation was also commented on many times. But no improvements were suggested implying that every student that tested this simulation thought the functionality of it was executed well and to a high standard.
17. The feedback for this question was all based off on the visual design of the 'Circular Motion' simulation and was, on the whole, very positive. The only improvement that was suggested was that the current design was too 'basic' in their opinion and so there could be more added to the simulation, yet the other two users didn't share this opinion and there are no more components to this practical that aren't displayed in the simulation, therefore, I do not plan on adding any extensions to this simulation.
18. The comments made for this question were, overall, very positive regarding the functionality of the 'Circular Motion' simulation. The only improvement that was suggested was to change the time period of the rotation based off of the inputs given by the student which is very possible as an extension and can be added with the use of a 'Timer' and changing the interval from the time period value.
19. This feedback was to gather an overall analysis of student's opinions of the program. Here, there were no negative comments, and it was mentioned that the visual design was 'easy to use', 'convenient' and 'well displayed'. It was also pointed out the 'SUVAT Solver' simulation may be the most useful.
20. The feedback for this question varied for each simulation but the overall average result for all simulations was that the simulations were 'Useful' and no simulation was ever rated anything lower than 'Somewhat Useful' which is very positive and shows that this program was something that students would use in future.
21. A similar question here has similar feedback. The three students were asked how likely they were to use the program in future and the average score for this was 7/10, which is very high and shows that there a high likelihood that the average student would want to use this program.
22. This final question was written to gather feedback of an overview of students opinions of the program, even if they didn't think they would use it in future. The average number of stars, out of 5, was 4.67, which shows that overall, the program was executed to a high standard for students' benefit, and they recognized that.

Was my project successful?

I believe that my project was successful for many different reasons. I think that I have achieved my aims and objectives because the program accurately interprets the real practicals in a way that is visually and mathematically no less accurate that in were to be carried out with the physical equipment. The program explains certain steps of the program so the students can grasp why they are inputting specific values and be explained to what the program is doing behind the scenes, mathematically, in a way that will be just as useful for the student to learn the process. The program is also quicker to carry out than the physical counterpart, therefore making it more time efficient. I researched existing practicals and found many issues that I solved in my simulations in the new program. I had to research each practical and how each one worked to be able to simulate the process of each one. I also, with the survey, found out what students find to be the most beneficial part of using simulations is, and what improvements they would make to currently used simulations, to focus my time on ensuring the students' needs and requirements were maintained if the transition was to be made from currently used simulations to the program of simulations developed as a part of this project and incorporating more thorough explanations for a better grasp of the information, from the students. Also, from the feedback it was clear to see that the overwhelming opinion was that of praise and students, determining that the program was 'useful' and rating it 4.67 out of 5 stars. Due to these many points, I conclude that this project was a success.

What did I learn?

I learned, from a personal perspective that I can trust myself to work independently and successfully gather and analyse feedback, being self-critical but constructive in my approach. I also learned that I need to improve with time management as, I didn't leave as much time as I would have liked for the analysis stage of my project. I could have gained this time by spending less time on design which was very detailed.

What improvements could be made?

On reflection, I believe that I could have spoken to more experts in their fields to perhaps understand more of a deeper knowledge of each practical that I was simulating and I could have spoken to other companies that create physics simulations to understand their approach and what works/doesn't work when they design and make simulations, to learn from their mistakes as to hopefully avoid them myself which would save time. I also think that I could have set more realistic expectations for myself as, if I'd have designed the simulation initially with less simulations in mind, then I believe I could have completed each one to a much higher quality e.g. creating a corresponding method for each simulation that a student could follow and use along side each simulation for their benefit. I also could have gathered feedback from teachers to understand the impressions it has on them if they may wish to use it as a teaching resource.

What is the impact of my project?

The impact this project has on the wider world is that all a-level students know can use the developed program for their own benefit. This could help with their revision techniques resulting in a higher end of year grade. This program provides an alternative, that in the opinions of students, is better than current simulations. This program can also help any teacher that teaches A-level physics as a useful way to provide quick answers to specific questions, allowing them to spend more time on more helpful parts of teaching, such as helping a student with an incorrect result. For example, with the 'SUVAT Solver' simulations, teachers can check whether the result that the student arrived at was correct but also whether or not their equation used and methodology was the most optimal, which then a student could then take forward into an exam saving them crucial time.

What did I have to research during the project?

During the design of my project there were many things that I had to research that I didn't research beforehand. This was intentional as I wanted to research as I was making to not forget about the research that I had done. I looked up every required practical that I used for inspiration with my simulations using 'Save My Exams' which is the name of a website containing a large amount of physics-based information.[9] I used it to view the equations and graphs used in each practical as a recap of the calculations involved and for simulations like the 'Capacitance' one, which was based off of a required practical, I used this website to find out what apparatus is used, the design of the circuit and the methodology at the forefront of the practical which was very useful when designing the look of the simulation.

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Project Log

Date	Action Taken	Expected Result (e.g. how long it is expected to take)	Actual Outcome (e.g. how did it take)	Learning Points (e.g. any reasons for a differing actual outcome or mistakes made)
17/09/2021	Form a strong direction for my project to go in with use of research to decide an exact direction for the project.	**2 hour(s)**	**2.5 hour(s)** The action was carried out well, after this stage I have a very clear understanding of the project I wish to carry out.	I underestimated how much time this would take me but am happy with the result, as now, I am certain in my mind, of the project direction.
24/09/2021	Research Existing Simulations and uncover faults with their designs.	**4 hour(s)**	**4 hour(s)** This action took as long as I expected as I wanted to spend a considerable amount of time to fully understand how I wish to be unique within my project and the problems I need to solve	N/A
01/10/2021	Begin with Introduction.	**1.5 hour(s)**	**1.5 hour(s)**	N/A
07/10/2021	Complete introduction.	**1 hour(s)**	**1.5 hour(s)** After this point, I am happy with my introduction.	Completing the introduction took longer than first anticipated, but I had to make necessary changes because I repeated myself twice in it.
10/10/2021	Begin Aims and Objectives.	**1.5 hour(s)**	**1.5 hour(s)** So far, I believe that the aims and objectives are suitable for the project.	N/A

16/10/2021	Complete Aims and Objectives.	**0.5 hour(s)**	**0.5 hour(s)** Again, I believe that the aims and objectives are suitable for the project so far.	There is more work that is needed to be done in this section, but I need more time to think about it.
16/10/2021	Complete the Contents for Completed.	**0.5 hour(s)**	**0.5 hour(s)** I have completed the contents for everything I have completed up until this point, successfully.	N/A
22/10/2021	Display Research in The Report for existing simulations	**1.5hour(s)**	**1.5 hour(s)**	N/A
29/10/2021	Create Survey to gather data on students' current opinions and perception of simulations in physics		**1.5 hour(s)**	N/A
5/11/2021	Share this survey in a-level physics related forums	**2 hour(s)**	**2 hour(s)** I didn't end up sharing the survey in forums and gave people feedback forms in person.	N/A
12/11/2021	Display the results from this survey in the report.	**3.5 hour(s)**	**6 hour(s)** I made graphs for all statistical results which took more time than initially expected.	N/A
26/11/2021	Write an overview of the feedback and consolidate students' opinions of the use of simulations in physics	**2 hour(s)**	**2 hour(s)**	N/A

03/01/2022	Determine an overall approach that my project will have	**1 hour(s)**	**2.5 hour(s)**	I first decided that the approach that I was going to take yet decided to change the number of simulations from 12 to 9 as to create better simulations.
05/01/2022	Reference and explain the reasoning behind the chosen IDE	**2 hour(s)**	**2 hour(s)**	N/A
06/01/2022	Decide on the 9 simulations and explain why each one was chosen.	**2 hour(s)**	**2.5 hour(s)**	Writing this took slightly longer than expected.
14/01/2022	Write an overview of what the User Interface should be like/include based off the feedback given by the students	**2 hour(s)**	**2 hour(s)**	N/A
15/01/2022	Create a Structure Chart for the program	**2 hour(s)**	**0.5 hour(s)**	This was much quicker than expected, as I already had a rough idea of the structure anyways.
17/01/2022	Draw, by hand, the initial ideas for the program and each simulation involved.	**2 hour(s)**	**4 hour(s)**	This took a longer amount of time due to the many different ideas that I had to consider.
18/01/2022	Create the design for the Opening Animation	**3 hour(s)**	**3 hour(s)**	N/A
19/01/2022	Write the explanation for the design of the Opening Animation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
20/01/2022	Create the design for the Home Page	**2 hour(s)**	**2 hour(s)**	N/A

25/01/2022	Write the explanation for the design of the Home Page	**1.5 hour(s)**	**1.5 hour(s)**	N/A
26/01/2022	Create the design for the Stationary Waves Simulation	**2 hour(s)**	**2 hour(s)**	N/A
26/01/2022	Write the explanation for the design of the Stationary Waves Simulation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
28/01/2022	Create the design for the Momentum Simulation	**2 hour(s)**	**3 hour(s)**	It took longer than expected to design the bumper cars as well as the form design
01/02/2022	Write the explanation for the design of the Momentum Simulation	**1.5 hour(s)**	**3.5 hour(s)**	N/A
03/02/2022	Create the design for the Projectile Motion Simulation	**2 hour(s)**	**2.5 hour(s)**	Took slightly longer due to planet and background concept designs
03/02/2022	Write the explanation for the design of the Projectile Motion Simulation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
05/02/2022	Create the design for the Moments Simulation	**2 hour(s)**	**2 hour(s)**	N/A
07/02/2022	Write the explanation for the design of the Moments Simulation	**1.5 hour(s)**	**1 hour(s)**	N/A
15/02/2022	Create the design for the SUVAT Solver Simulation	**2 hour(s)**	**2 hour(s)**	N/A

15/02/2022	Write the explanation for the design of the SUVAT Solver Simulation	**1.5 hour(s)**	**1 hour(s)**	N/A
18/02/2022	Create the design for the Ohm's Law Simulation	**2 hour(s)**	**2 hour(s)**	N/A
20/02/2022	Write the explanation for the design of the Ohm's Law Simulation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
21/02/2022	Create the design for the Capacitance Simulation	**2 hour(s)**	**1.5 hour(s)**	N/A
21/02/2022	Write the explanation for the design of the Capacitance Simulation	**1.5 hour(s)**	**1 hour(s)**	N/A
23/02/2022	Create the design for the Circular Motion Simulation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
23/02/2022	Write the explanation for the design of the Circular Motion Simulation	**1 hour(s)**	**1 hour(s)**	N/A
24/02/2022	Begin work on the structure of the program	**2 hour(s)**	**2.5 hour(s)**	Took longer than expected to add and name all the forms and modules.
25/02/2022	Complete the structure of the program including all navigational buttons	**2.5 hour(s)**	**2.5 hour(s)**	N/A
25/02/2022	Begin work on the Stationary Waves Simulation	**4 hour(s)**	**4 hour(s)**	N/A

26/02/2022	Finish the layout of the Stationary Waves Simulation	**1.5 hour(s)**	**2 hour(s)**	Took slightly longer due to a change in plan from the initial planned layout.
26/02/2022	Create the design of the Stationary Waves simulation and create the animation	**2 hour(s)**	**5.5 hour(s)**	The aspects of the design took longer than expected to add to the program. The motion in the program also took more time than expected
27/02/2022	Finalise the calculations within the code and implement exception handling within the simulation	**4 hour(s)**	**4.5 hour(s)**	N/A
27/02/2022	Complete the Stationary Waves Simulation	**1 hour(s)**	**1.5 hour(s)**	N/A
27/02/2022	Begin work on the Momentum Simulation	**5 hour(s)**	**5 hour(s)**	N/A
28/02/2022	Finish the layout of the Momentum Simulation	**1.5 hour(s)**	**1 hour(s)**	Took less time than expected due to a simple layout
01/03/2022	Create the design of the Momentum simulation and create the animation	**2 hour(s)**	**4 hour(s)**	This took a much longer amount of time than expected due to a complex animation including many different variables dependent on the users input
01/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**1 hour(s)**	**1 hour(s)**	N/A

01/03/2022	Complete the Momentum Simulation	**1 hour(s)**	**1.5 hour(s)**	Took slightly longer to finalise the user interface
02/03/2022	Begin work on the Projectile Motion Simulation	**4 hour(s)**	**4 hour(s)**	N/A
02/03/2022	Finish the layout of the Projectile Motion Simulation	**1.5 hour(s)**	**2 hour(s)**	There were many components to this simulation so they layout took a short while longer to perfect.
04/03/2022	Create the design of the Projectile Motion simulation and create the animation	**4 hour(s)**	**6 hour(s)**	To be able to change the angle with a slider and for that angle to then be displayed smoothly on the display took many attempts to get right which is why it took longer than expected.
04/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**1 hour(s)**	**2 hour(s)**	Took slightly longer to incorporate all of the different calculations with each of the surfaces that the object has the potential to be projected from.
05/03/2022	Complete the Projectile Motion Simulation	**1 hour(s)**	**1.5 hour(s)**	N/A
06/03/2022	Begin work on the Moments Simulation	**3.5 hour(s)**	**3.5 hour(s)**	N/A
06/03/2022	Finish the layout of the Moments Simulation	**2 hour(s)**	**2 hour(s)**	N/A

06/03/2022	Create the design of the Moments simulation and create the animation	**5 hour(s)**	**5.5 hour(s)**	Took slightly longer than expected due to the number of different scenarios that the balancing system could be in that had to be designed.
07/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**1 hour(s)**	**1.5 hour(s)**	N/A
07/03/2022	Complete the Moments Simulation	**1 hour(s)**	**1.5 hour(s)**	Took slightly longer due to slight adjustments in the design to improve the overall look.
08/03/2022	Begin work on the SUVAT Solver Simulation	**2 hour(s)**	**2 hour(s)**	N/A
08/03/2022	Finish the layout of the SUVAT Solver Simulation	**2 hour(s)**	**1 hour(s)**	Didn’t take long due to the very simple layout design
09/03/2022	Create the design of the SUVAT Solver simulation and create the animation	**3 hour(s)**	**2.5 hour(s)**	Took less time than expected to only slight changes made from the design made.

10/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**5 hour(s)**	**8 hour(s)**	Took a very long time due to the possible number of combinations that the user could enter, and the simulation had to calculate based upon. Also displaying the method was a long process again, due to the quantity of different options. Exception handling was also something which took a long time to perfect with no errors.
11/03/2022	Complete the SUVAT Solver Simulation	**1 hour(s)**	**1.5 hour(s)**	N/A
11/03/2022	Begin work on the Ohm's Law Simulation	**2 hour(s)**	**2 hour(s)**	N/A
11/03/2022	Finish the layout of the Ohm's Law Simulation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
12/03/2022	Create the design of the Ohm's Law simulation and create the animation	**3 hour(s)**	**3.5 hour(s)**	Took slightly longer due to the design of the ammeter and movement of the resistor.
14/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**1 hour(s)**	**1 hour(s)**	N/A
14/03/2022	Complete the Ohm's Law Simulation	**1 hour(s)**	**1 hour(s)**	N/A
15/03/2022	Begin work on the Capacitance Simulation	**2 hour(s)**	**2 hour(s)**	N/A

15/03/2022	Finish the layout of the Capacitance Simulation	**1.5 hour(s)**	**2.5 hour(s)**	Did take longer due to more component than were initially in the design, such as the way to slow down/speed up the timer.
16/03/2022	Create the design of the Capacitance simulation and create the animation	**3 hour(s)**	**2 hour(s)**	Was simple due to the simple design of the circuit.
16/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**1 hour(s)**	**1.5 hour(s)**	The calculations used a 'Timer' object which made them slightly longer to complete.
17/03/2022	Complete the Capacitance Simulation	**1 hour(s)**	**1 hour(s)**	N/A
18/03/2022	Begin work on the Circular Motion Simulation	**2 hour(s)**	**2 hour(s)**	
18/03/2022	Finish the layout of the Circular Motion Simulation	**1.5 hour(s)**	**1.5 hour(s)**	N/A
19/03/2022	Create the design of the Circular Motion simulation and create the animation	**3 hours**	**2.5 hour(s)**	Took many different attempts for the design of the system to look right, but still took less time than initially expected

19/03/2022	Finalise the calculations within the code and implement exception handling within the simulation	**1 hour(s)**	**1.5 hour(s)**	Took longer than expected to implement the exception handling which was a very prominent / necessary part of this simulation due to all the user inputs.
21/03/2022	Complete the Circular Motion Simulation	**1 hour(s)**	**1 hour(s)**	N/A
23/03/2022	Create an illustration for each home page button and complete the Home Page	**4 hour(s)**	**4 hour(s)**	I spent roughly half an our on each illustration
23/03/2022	Begin work on the Opening Animation	**3 hour(s)**	**3 hour(s)**	N/A
24/03/2022	Finish the Opening Animation	**5 hour(s)**	**5 hour(s)**	N/A
25/03/2022	Add a menu to each simulation which includes all the settings necessary for that simulation.	**3.5 hour(s)**	**4 hour(s)**	N/A
26/03/2022	Add message boxes that are to be displayed, which may show equations, equipment, and more information about the simulation, to the menu.	**3 hour(s)**	**3 hour(s)**	N/A
26/03/2022	Compare the results of the simulations to the initial planned design.	**1 hour(s)**	**1.5 hour(s)**	N/A

27/03/2022	Begin work on the feedback form to hand out to students.	**2 hour(s)**	**2 hour(s)**	N/A
29/03/2022	Add more questions to the feedback form.	**2 hour(s)**	**1.5 hour(s)**	N/A
30/03/2022	Complete all questions for the feedback form by adding general overview questions at the end.	**1 hour(s)**	**0.5 hour(s)**	These questions were much easier to write so took less time than expected.
10/04/2022	Complete the feedback form with a brief description for the students that will test the program.	**0.5 hour(s)**	**0.5 hour(s)**	N/A
13/04/2022	Begin to evaluate the reason behind asking each question.	**2.5 hour(s)**	**2.5 hour(s)**	N/A
14/04/2022	Evaluate more questions.	**2 hour(s)**	**2 hour(s)**	N/A
16/04/2022	Complete the evaluation of all questions	**2 hour(s)**	**3.5 hour(s)**	Took longer than expected to evaluate question 20
17/04/2022	Write an overview of all opinions and outcomes gathered from the feedback	**2 hour(s)**	**2 hour(s)**	N/A
18/04/2022	Allow the first student to test the program and provide feedback.	**1.5 hour(s)**	**1.5 hour(s)**	N/A
25/04/2022	Allow the second student to test the program and provide feedback.	**1.5 hour(s)**	**1.5 hour(s)**	N/A

26/04/2022	Allow the last student to test the program and provide feedback.	**1.5 hour(s)**	**1.5 hour(s)**	N/A
01/05/2022	Write a reflection to conclude the project	**3 hour(s)**	**1.5 hour(s)**	Had to finish early and complete at a later date.
02/05/2022	Complete reflection	**2 hour(s)**	**2 hour(s)**	N/A
13/05/2022	Write Abstract	**1.5 hour(s)**	**1.5 hour(s)**	N/A

Total Time Taken

1.348214 weeks | 9.4375 days | 226.5 hours | 13,590 minutes | 815,400 seconds