Analysis

Computer science NEA Analysis section

Overview

At higher levels in physics and maths, the motion that equations refer to and diagrams can become unclear and so there is a need for a clear and concise physics simulation that can show students what the model actually portrays, which allows the student to better visualise the question. Having a physics simulator that is easy to interpret, use and collect data from would be of benefit to the learning of the student, which is where my program would be of use. As-well as helping the students overcome present issues, getting students used to using simulators is a good way to prepare them for future, far more complex, simulation systems at higher levels of education and the work force as large complex and expensive experiments are not done very often to conserve money.

Research into topic

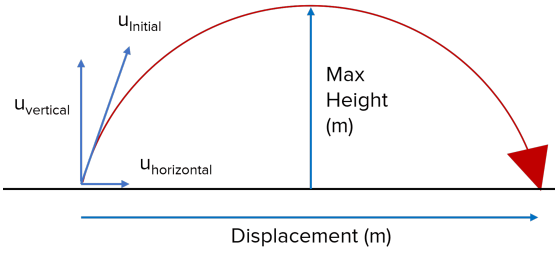
I can use my personal knowledge of the A-level and GCSE physics syllabus to determine the simulations I should create and check their validity via the internet. I also receive suggestions for simulations from my customer and Physics teacher Mr Beckingham.

Experiments that I will model will be researched with appropriate calculations are listed in the following table.

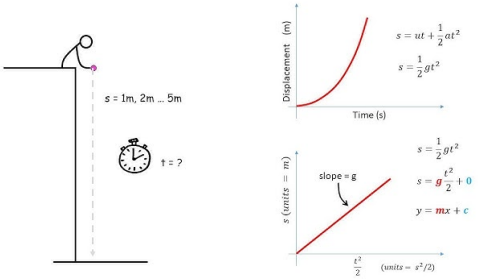
Describing the Models

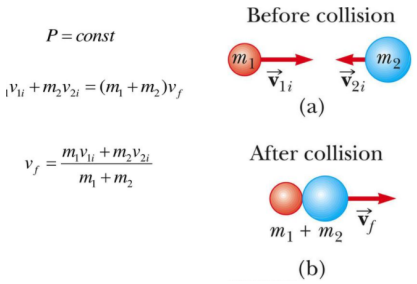
Experiment	Description	Diagrams / Reference
Freefall	A mass falls from a height and comes to rest at the ground.	experiment image 1
Projectile Motion	A mass is launched at a speed, and will fall to the ground where it will stop instantly. The speed will most likely remain constant unless air resistance is modelled (which is difficult and aspirational).	experiment image 2
Object sliding down a slope	A mass slides down a slope, friction may be modelled as a force acting against the movement of the mass, if the force cannot be overcome the mass will not move.	experiment image 3

Experiment Image 2

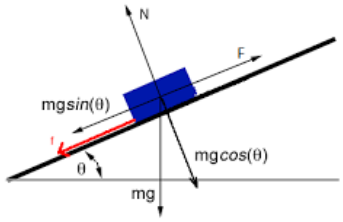


Experiment Image 1





Experiment Image 4



Experiment Image 3

Experiment	Description	Diagrams / Reference
Inelastic collision on a flat plane	Two masses of variable size (not necessarily identical masses), moving at variable speeds (not necessarily identical either) colliding on a flat plane and then sliding one way or the other or stopping out right.	experiment image 4

References

Freefall

A-level physics practical, Also in GCSE Diagram: https://i.ytimg.com/vi/K6dMoyM2B-A/hq720.jpg?sqp=-oaymwEhCK4FEIIDSFryq4qpAxMIARUAAAAAGAElAADIQj0AgKJD&rs=AOn4CLD1I A from video: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3 A&psig=AOvVaw2QhONOAC_PbS36koLYbNVf&ust=1744274371126000&source=images&cd=vfe&opi=899 . Practical 3 on: https://www.aqa.org.uk/resources/science/as-and-a-level/physics-7407-7408/teach/practicals-apparatus-set-up-guides

Projectile Motion

Common question in A-level physics and mathematics Diagram: https://mmerevise.co.uk/a-level-physics-revision/projectile-motion/

Mass on a slope

Common question in A-level mathematics Diagram: https://homework.study.com/explanation/a-mass-m-14-0-kg-is-pulled-up-an-incline-plane-by-a-f-85-n-the-plane-angle-is-26-degrees-with-respect-to-the-horizontal-the-coefficient-of-friction-between-the-block-and-the-surface-is-0-30-a.html . Examples of A-level mass on a slope calculations: https://pmt.physicsandmathstutor.com/download/Maths/A-level/M1/Topic-Qs/Edexcel-Set-1/M1%20Dynamics%20-%20F%20=%20ma%20on%20a%20slope.pdf

Inelastic collision on a flat plane:

Question in A-level physics Diagram: https://physics.stackexchange.com/questions/685887/perfectly-inelastic-collision-moving-and-spinning-wheels ### Calculations needed for models

Exp	Calculations needed	Equation(s)
Free-fall	SUVAT equation to solve for speed and height at individual points using time and acceleration	$v = u + at$ where $a = g$, t is time since the start of the simulation, and $u = 0$. then $s = ut + \frac{1}{2}at^2$, where $u = 0$ so $ut = 0$ so $s = \frac{1}{2}gt^2$ because a = g, (g=gravity),

Exp	Calculations needed	Equation(s)
Projectile motion	Freefall equations also linked with forward movement equations to calculate the distance	freefall equations (listed above) + forward equations for constant velocity: $s = \frac{1}{2}(u+v)t$ where u=v so $s = \frac{1}{2}(2u)t = ut$ so $s = ut$
Object sliding down a slope	Equations linking the resultant force of the block sliding down the slope linked to the angle of the slope.	$mgsin\theta$ where θ is the angle of the slope from the horizontal plane, m is the mass of the block and g is the force of gravity. The available angles may have to be hard coded or restricted as I am unsure of whether sine can be used in python
Inelastic object collision on a flat plane	Equations linking the mass and speed of the masses to their inertia and then equations to display the transfer of inertia and determine the resultant direction of travel for the two masses	Start the masses off with $d = vt$ until they collide where the following decides their motion afterwards: $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ where m is the mass and v is the velocity and v_f is the final velocity of both masses.

Project deliverables

The Program should contain the discussed models and use their calculations accurately

Potential simulations for the program: - Freefall - Projectile Motion - Object sliding down a slope - 2 objects of varying masses colliding on a single plane

The program should also be able to utilise pygame's graphical features to portray the simulations in an animated form and tell the user the key properties of the simulation live on screen

Prototypes To prototype what I plan to do I wrote two programs: I followed a tutorial to demonstrate how a block could be manipulated around a screen which is beyond what I have to achieve & I wrote the code to spit out results for the free fall model which were then put into a file

Project Requirements

No.	Section	Requirement
1	Menu	The main menu should lead the user to choose what experiment to do or exit

No.	Section	Requirement
2	Menu	User should be able to select an option on the menu
3	Menu	User should be able to see what option they've selected
4	Menu	The sub menus should contain the experiments
5	Menu	The menus should refresh soon after any update
6	Menu	The menu should tell the user the controls
7	Menu	The menu should allow the user to quit the program
8	Menu	**ASPIRATIONAL:** The user should be able to select options by clicking with the left mouse button
9	Results	Results should be stored in files related to each individual experiment
10	Results	Results should overwrite previous results in the experiment file
11	Results	Results should be stored in SI units
12	Results	Results stored in a file should be written in a format that the program can interpret
13	Experiment Usage	The user should be able to go back from a menu to the previous menu they were on
14	Experiment Usage	The user should able to replay the experiment
15	Experiment Usage	The experiment should be simulated accurately relative to time
16	Experiment Usage	The user should be able to edit parameters before the experiment
17	Experiment Usage	The scale of the projection should be that which maximises the usage of the window to provide the highest visual resolution of the experiment
18	Experiment Usage	The table of values that the projection is made from should be accessible to the user after the visualisation of the experiment is complete
19	Experiment Usage	The user should be able to end the program from each menu
20	Experiment Usage	Invalid user inputs should be rejected
21	Experiment Usage	When a user input is rejected the user should be prompted to re-enter the value
22	Exp 1	Experiment demonstrating a block falling from a height and coming to instantaneous rest on the floor must be simulated
23	Exp 1	Experiment must calculate the velocity, height / distance from start, and time since the start of the simulation
24	Exp 1	The experiment should be modelled as a block starting from an aloft point on the screen, from which the block falls to the floor (where it stops falling)
25	Exp 2	Experiment demonstrating a block in projectile motion and coming to instantaneous the floor must be simulated

I'm sorry for overlap, I tried my best to fix

No.	Section	Requirement
26	Exp 2	The experiment will use calculations of the velocity, height and distance along the floor at each time interval to produce the simulation to an accurate scale in time and distance
27	Exp 3	Model accurately demonstrating a block sliding down a slope
28	Exp 3	The sloped plane, as-well as the block, must be modelled.
29	Exp 4	Model accurately depicting an inelastic collision between two blocks
30	Exp 4	The model must show the blocks from when they're moving toward each other all the way up until an appropriate time after the collision to allow the user to witness the resultant direction of travel or lack there of.