SPL-1 Project Report -2022

"LearnPhysics"

SE 305: Software Project Lab 1

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Project Name : LearnPhysics (A Physics based learning Application)

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ACKNOWLEDGEMENT

I would like to express my deep and sincere gratitude to my Software Project Lab -1 Supervisor, Dr. Emon Kumar Dey Sir, Associate Professor, Institute of Information Technology(IIT), University of Dhaka, for giving me the opportunity to do this project and providing invaluable guidance throughout the entire course. His dynamism, vision, sincerity and motivation have deeply inspired me. It was a great privilege and honor to work under his guidance.

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1. Introduction

LearnPhysics is an Physics based Application for learning with visualization. Any student/user can learn the topics of Physics, such as Projectile Motion, Momentum, Vector etc. by this Application. In our country the learning style for school and college level students is monotonous and difficult, for which this project can be an effective way to make the learning easier and attractive with visualization . In this project graphics are used for the animations of every feature using graphics.h in C++. LearnPhysics is implemented for achieving the goals of interactive learning. With the help of this project, a student can make a huge progress in Physics by learning, experimenting and visualizing.

1.1. Background Study

For implementing this project, prior studies were necessary. These are given below:

i. Projectile:

A projectile is any object thrown into space upon which the primary acting force is gravity. It moves along a curved path under constant acceleration that is directed towards the center of the earth. In my project, this is the main topic on which the visualization has been made. Mathematical equations of motion are used to analyze projectile motion.

Projectile Motion formulas are given by:

1. Time to reach maximum height (T): The time taken for the projectile to reach the maximum height from the plane of projection.

$$T_{max} = \frac{Vo\ Sin(\alpha)}{g}$$

2. Time of Flight (T): This is the total time taken for the projectile to fall back to the same plane from which it was projected.

$$2T_{max} = \frac{2Vo\ Sin(\alpha)}{g}$$

3. Maximum Height (H): This is the maximum height attained by the projectile.

$$H_{max} = \frac{Vo^2 Sin^2(\alpha)}{2g}$$

4. Horizontal Range (R): The Range of a projectile is the horizontal distance covered (on the x-axis) by the projectile.

$$R_{max} = \frac{Vo^2 Sin\ (2\alpha)}{g}$$

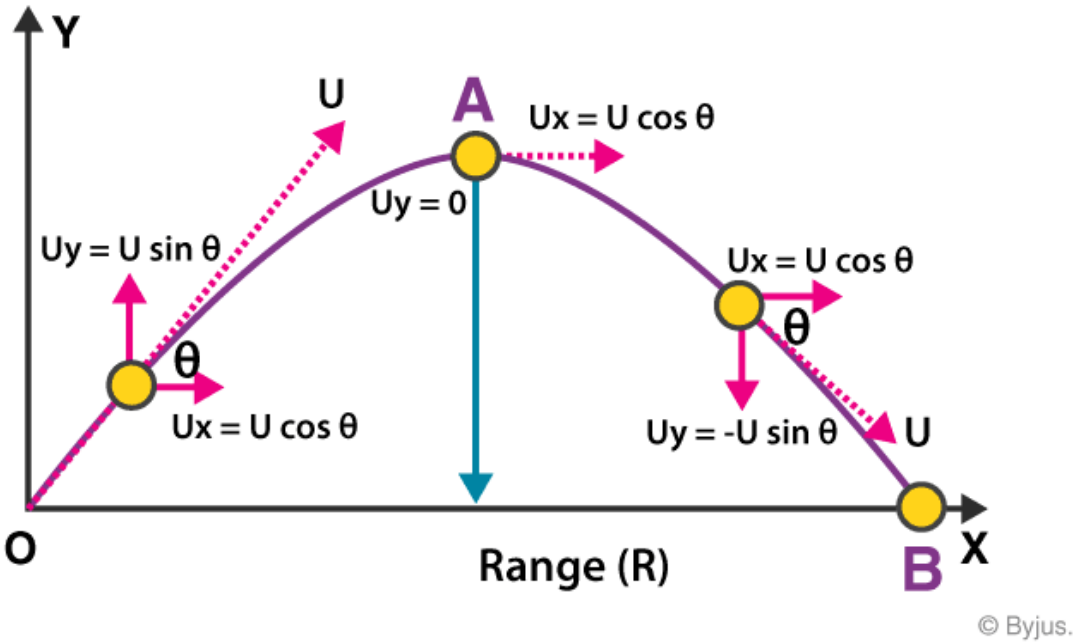
5. Velocity: Velocity that is gained by the projectile at any time(t).

$$V_X = Vo\ cos(\alpha)$$

$$V_y = Vosin(\alpha) - gt$$

$$V = \sqrt{V_X^{\ 2} + V_y^{\ 2}}$$

A figure is shown below showing how the velocities change according to time.



source:https://cdn1.byjus.com/wp-content/uploads/2020/07/Projectile-Motion-1.png s

Figure-01: Projectile motion:

2. **Vector analysis:**

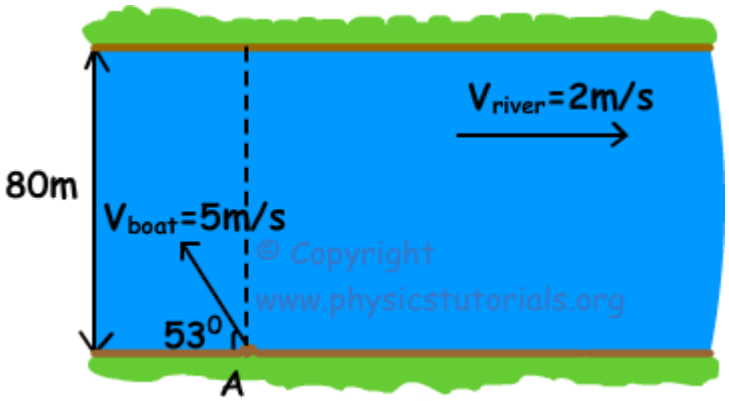
Boat crossing river problem is implemented in this project:

Formula used :

$$R=\sqrt{P^2 + Q^2 + 2PQcos(\alpha)}$$

$$\tan(\theta) = \frac{Qsin(\alpha)}{P+Qcos(\alpha)}$$

R=Resultant vector
P= 1st object velocity
Q=2nd object velocity
α=Angle between P and Q
θ= Angle between resultant velocity and velocity (P)



source:https://www.physicstutorials.org/images/Exams/Kinematics/riverboat_1.png

Figure-03: Boat crossing river :

3. Conservation of Momentum:

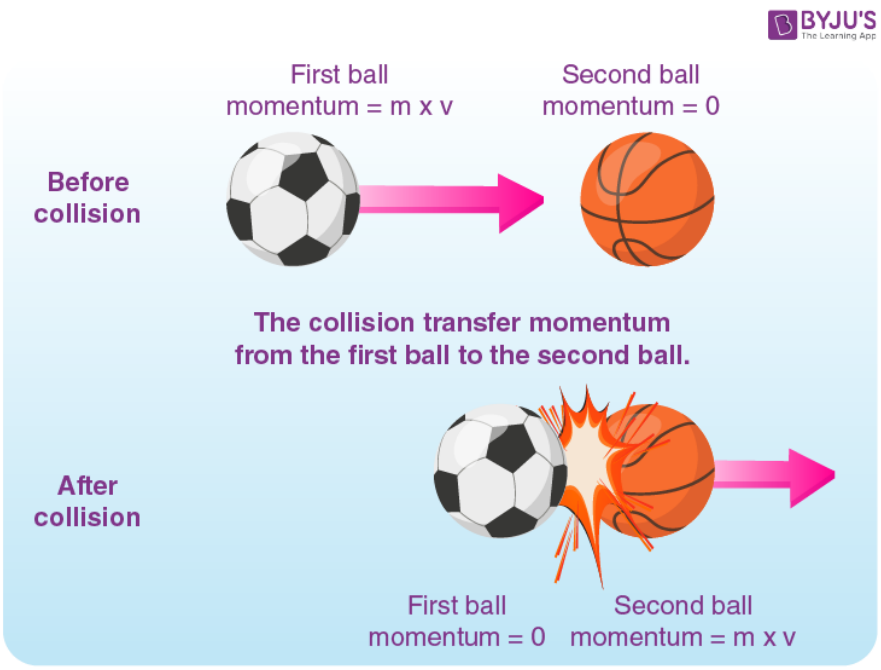
Conservation of momentum mostly refers to collisions between objects. "For a collision occurring between object 1 and object 2 in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision". That is, the momentum lost by object 1 is equal to the momentum gained by object 2 ,

Formula used for momentum :

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

m_1=Mass of 1st object
u_1= Initial velocity of the 1st object
m_2=Mass of 2nd object
u_2=Initial velocity of 2nd object
v_1=Final velocity of object of 1st object
v_2=Final velocity of second object.

A picture is given below how this work:



source:https://cdn1.byjus.com/wp-content/uploads/2023/04/Conservation-of-Momentum-Derivation-and-Principles-04.png

Figure-02: Conservation of momentum.

1.2. Challenges

1.**Complex equations**: Projectile motion involves multiple variables such as initial velocity, angle of projection, time of flight, and height of the launch point. The equations used to calculate these variables can be complex

2.**Multiple dimensions**: Projectile motion occurs in two dimensions (horizontal and vertical). Visualizing the motion accurately in both dimensions can be challenging, particularly when considering factors like scale, perspective etc.

3.**Real-time update**s: In some cases, we may want to display the projectile's trajectory in real-time, showing the updated position as the motion progresses. This requires continuous calculations and updates, which can be computationally intensive, especially for complex scenarios or large datasets.

Overcoming these challenges often requires a combination of mathematical understanding, programming skills, and visualization techniques. Using appropriate numerical methods, simulation frameworks, and visualization libraries can help simplify the process and provide accurate results for projectile motion problems.

Vector analysis:

1.**Vector calculations**: River crossing boat problems often involve vector calculations to determine the boat's resultant velocity or displacement. Implementing vector operations, such as vector addition or subtraction, in C++ can be complex, especially when dealing with multiple dimensions.

2.**Trigonometric functions**: River crossing problems typically require trigonometric functions like sine, cosine, and tangent to calculate the boat's velocity components. Ensuring correct usage of these functions and handling angle conversions (degrees to radians) can be challenging.

3.**Visualization techniques:** Visualizing river crossing boat problems can aid in understanding and analyzing the solution. Implementing graphical elements, such as arrows or vectors, to represent velocities and displacements requires knowledge of graphics libraries or frameworks in C++.

3**. Conservation of Momentum:**

1.**Handling multiple objects:** Conservation of momentum problems often involve multiple objects interacting with each other. Tracking and managing the momentum of each object can become complex, especially when considering various directions and magnitudes.

2.**Collision detection and response:** If the conservation of momentum problem involves collisions between objects, accurately detecting collisions and determining the resulting velocities or momenta can be challenging.

3.**Real-time updates**: For dynamic scenarios, you may want to visualize the conservation of momentum problem in real-time, showing the updated positions and velocities of objects as the simulation progresses. This requires continuous calculations and updates, which can be computationally intensive, especially for complex scenarios or large datasets.

2. Project Overview

To make it easy and fun It will visualize those formulas. The
application generally uses these steps.

Step 1: The user will enter the formula's required parameters.

Step 2: This application analyzes the data.

Step 3: It solves the required problem.

Step 3: It shows a visualization of the problem using data

The following tasks will be performed by this application.

➢ Projectile Motion
- Height of projection
- Horizontal Distance
- Velocity at any time
- Time to travel

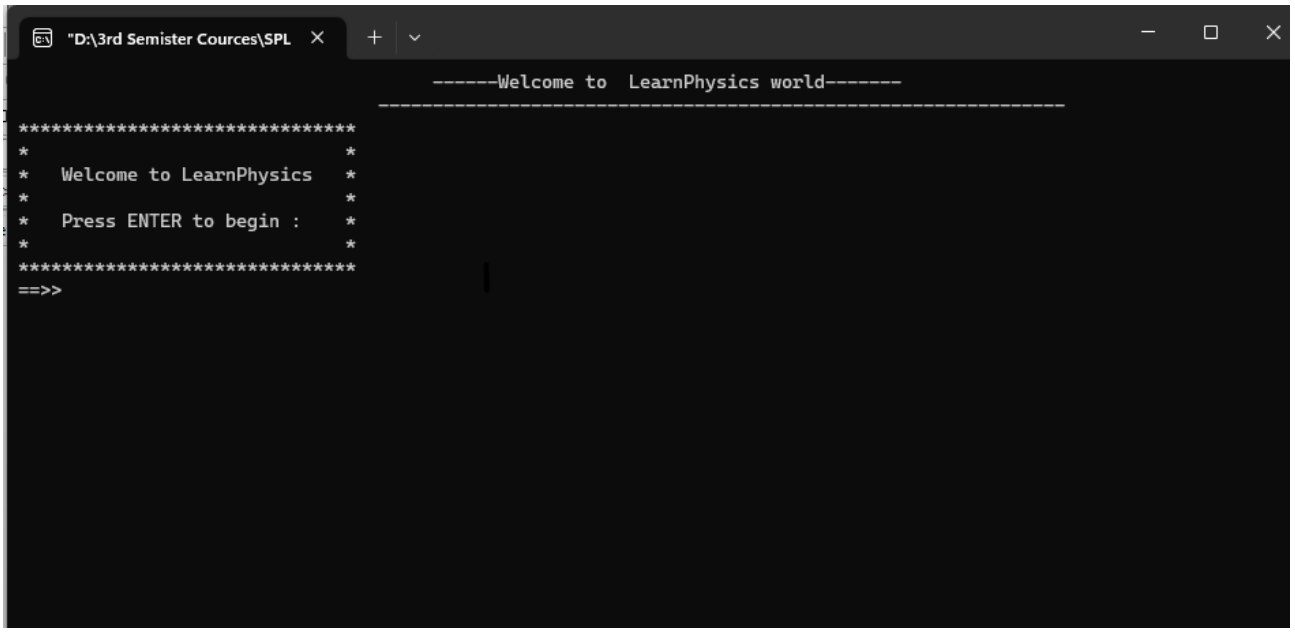
➢ Vector analysis
- Boat crossing river vector problem

➢ Mechanics
- Conservation of momentum

3. User Manual

Complete user manual with installation, usage procedure with screenshots, Sample Input/output.

Users can enter the Application by pressing the Enter button. After getting to the menu page, users will see the list of topics.



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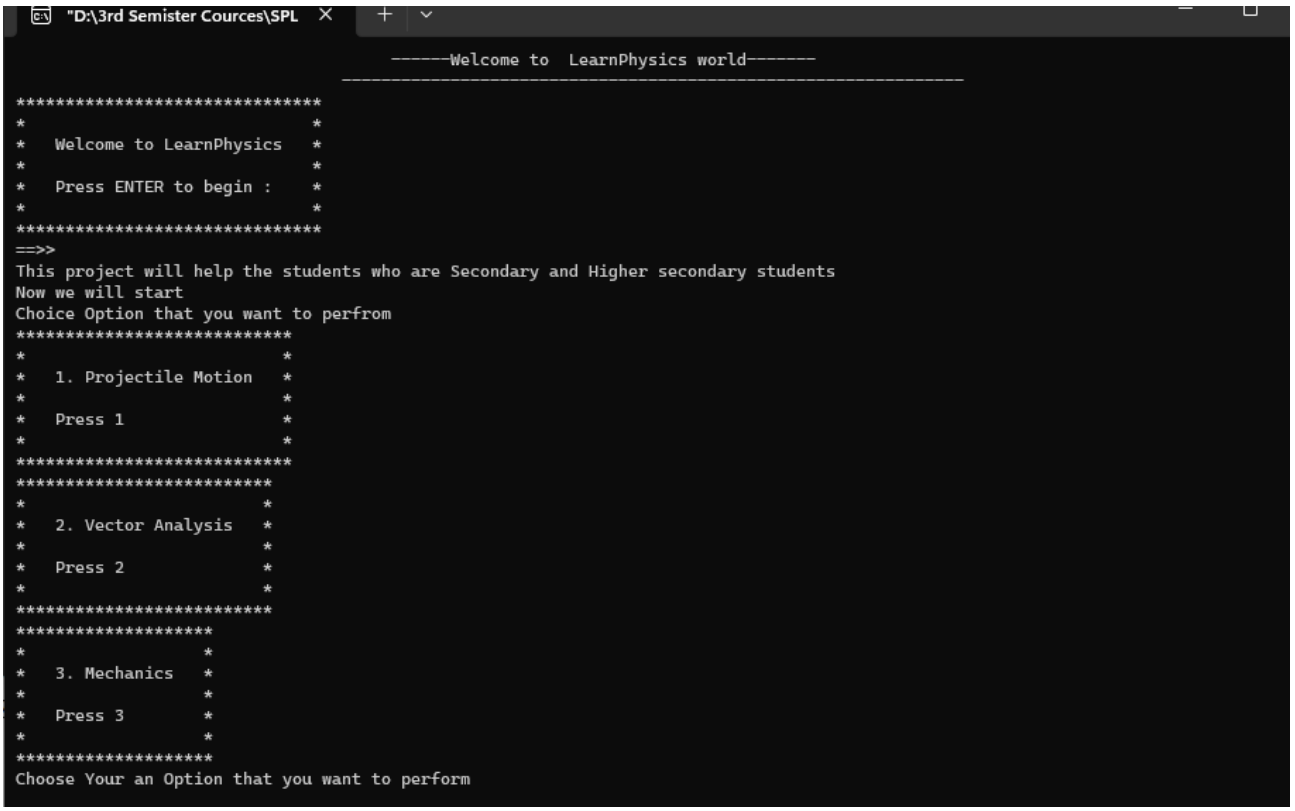
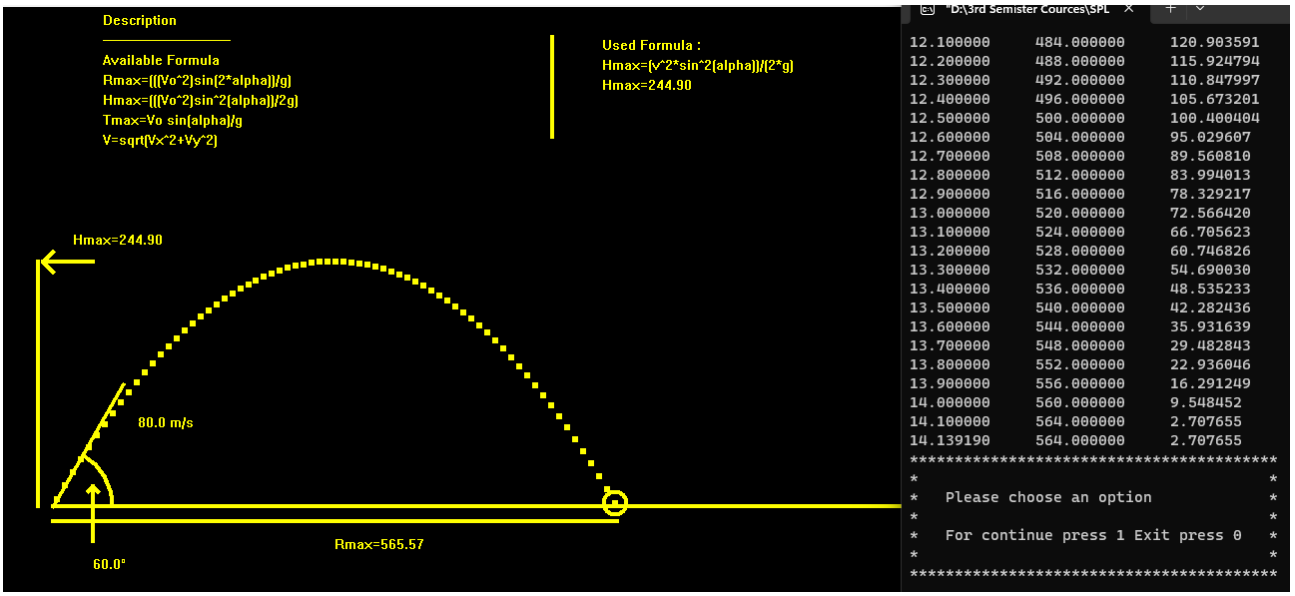


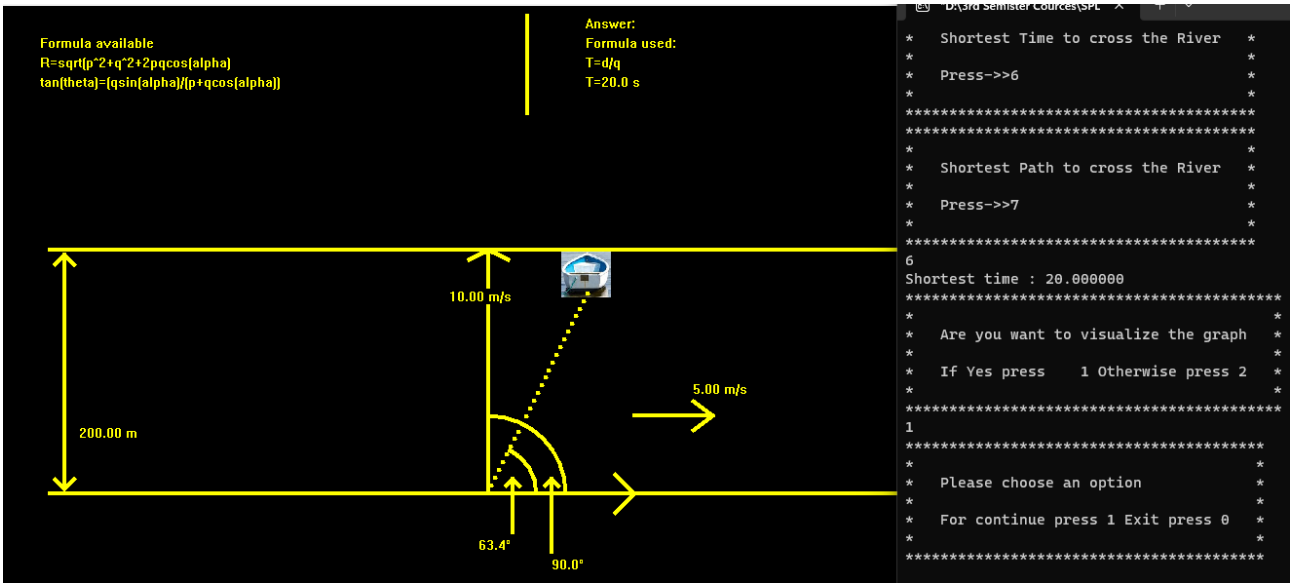
After choosin 1 option user will be able to solve desired problem with visualization:



Visualization projectile motion

Step by step calculation

Choosing 2 option users can solve the required problem with visualization.



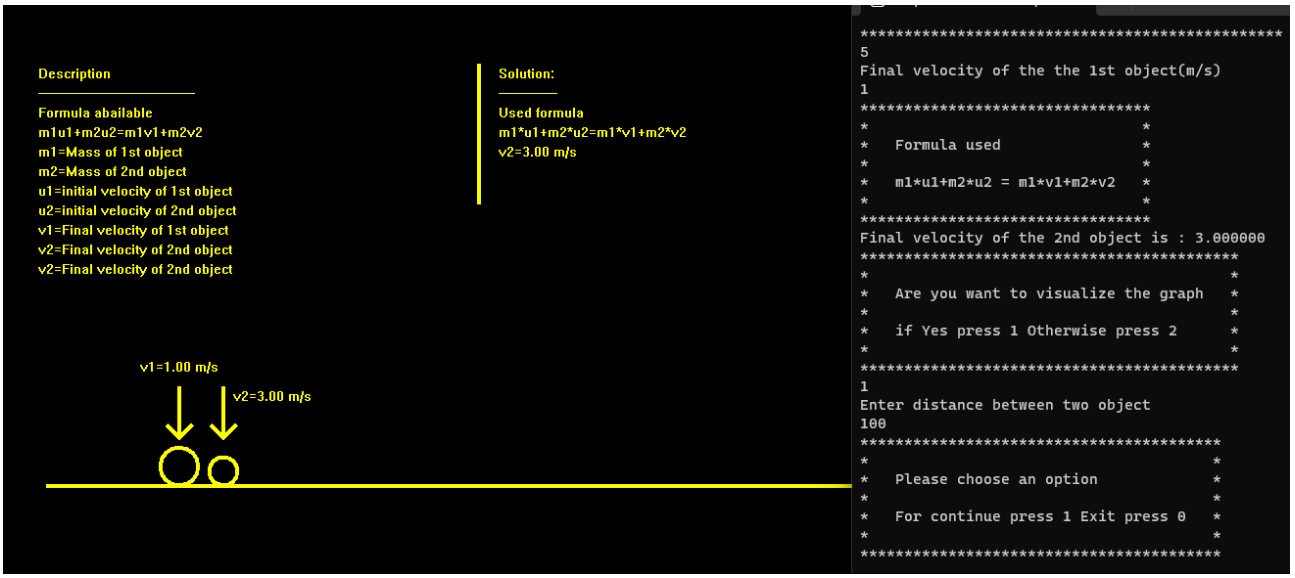
Vector analysis

Required solution

Choosing 3 optionUser can see the following feather:

Momentum visualization

Formula



Momentum visualization

Formula

Before collision:

Object 1 has mass m1 and velocity u1

Object 2 has mass m2 and velocity u2

The total momentum before collision is define as

$m_1u_1 + m_2u_2$

After collision:
Object 1 has mass m1 and velocity v1
Object 2 has mass m2 and velocity v2

The total momentum after collision is define as :

$m_1v_1 + m_2v_2$

By equaling the total momentum before and after collision, we solve for the velocities after the collision..

4. Conclusion

For making this project, firstly I learnt all the basic animation concepts of Graphics and Algorithms. Then used them to make the simulations. As the project is made for the students of secondary and higher secondary level students,For that I made the options, calculation and visualization with graphics in c++ for better experience, then added to the project accordingly. Visualizing everything, including the answers was the main target of this project.I look forward to making more user-friendly learning applications so that the students learn the subjects in an interesting way. Also, I want to extend this project further by adding new topics and features.

5.Appendix

Github link of the project:

https://github.com/Nasir-1310/SPL-1

6.References

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