Experiment P-49

Horizontal Launched Projectile Motion

Physics

Objectives

- To understand the concepts of projectile motion and trajectories.
- To predict the landing point of a ball by measuring its initial horizontal velocity.
- To generate different velocities and observe the compatible motion pattern.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-209 Photo gate logger sensor

Equipment and Accessories

▪ Utility stand
▪ Right angle clamp
▪ Extension clamp
▪ 60 cm wooden lever ruler
▪ Rough and smooth wooden block with hook
▪ 3 m measuring tape
▪ Small ball (3.5 cm in diameter)

- We recommend using a sponge ball for this experiment.

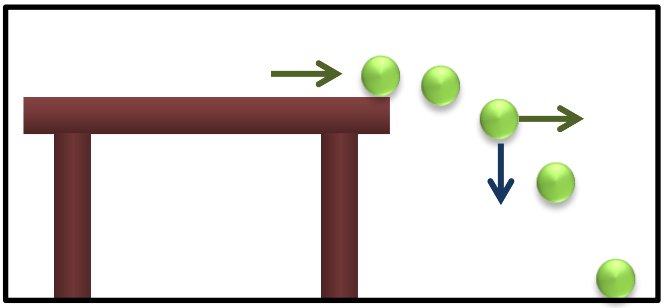
- The items above are included in the NeuLog Mechanics kit, MEC-KIT (except for the small ball). If you do not have the kit, you can use your own setting for a ramp.

Introduction

A projectile is any object that is cast, fired, tossed or thrown. The path of a projectile is called its trajectory. This can describe, for instance, the motion of a baseball, a bullet, or a car driven off a cliff. When an object is thrown in the air, the initial velocity, angle and position will predict how much time it will be in the air and where it will fall down.

Horizontal launched projectile motion happens when the object is launched with an initial horizontal velocity from an elevated position and follows a parabolic path to the ground. This differs from a projectile that is launched at an angle.

This is an example of a ball pushed away from a table (horizontal launch):



The ball is pushed horizontally with no upwards angle and with an initial speed of 0.3 m/s. If there were no gravity, the ball would continue its motion at 0.3 m/s in the horizontal direction. The force of gravity causes the ball to accelerate downwards at a rate of 9.8 m/s^2.

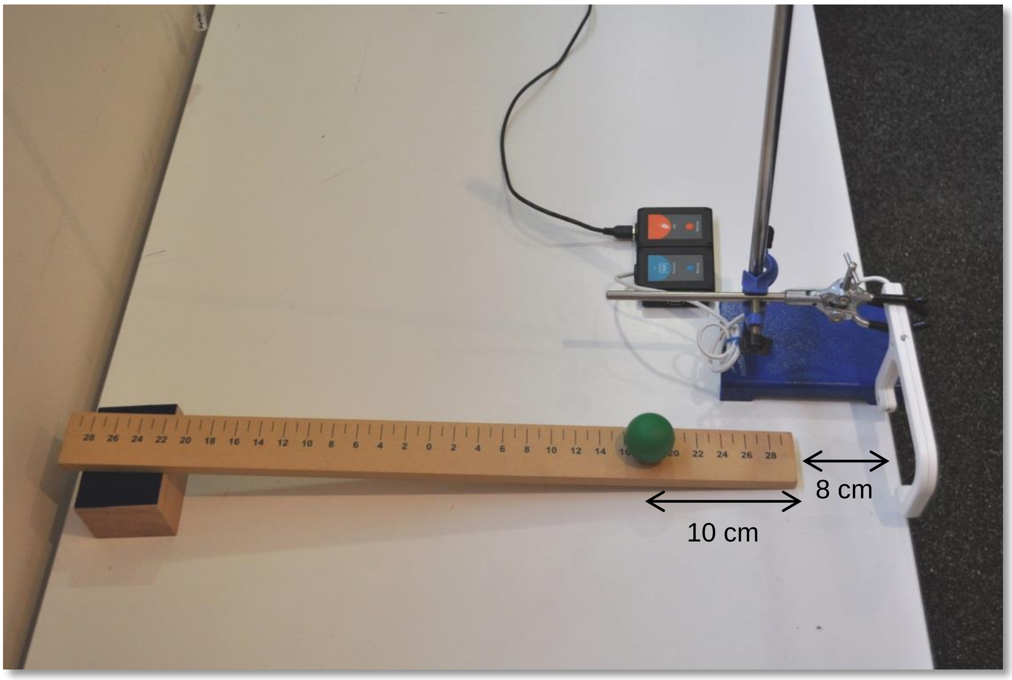
The ball's motion has two components, horizontal and vertical; these components are perpendicular, therefore they are independent of each other. When solving horizontal launch problems, we have to consider these concepts: the **horizontal velocity remains constant** until the ball hits the ground while the **vertical velocity increases by 9.8 m/s every second**, although for this to be true we have to neglect air resistance force.

In this experiment we will let a ball to fall down a ramp, in order to measure its horizontal velocity when it is rolling on a table, using a photo gate logger sensor. Its landing point on the ground will be predicted and then compared to the one measured with measuring tape.

Procedure

Experiment setup

1. Set up the experiment as shown in the picture below.



2. Put the lever ruler on the wooden block in order to set up a ramp.

3. Connect the right angle clamp and the extension clamp to the Utility stand.

4. Connect the photo gate to the utility stand with the extension clamp.

5. The position of all the items should be like in the picture above so that the ball can be rolled down the ramp and then through the photo gate.

6. Position the photo gate to a height in which its beam (that comes out of one of the photo gate's arms) will project to the middle of the ball. You will insert the diameter of the ball and it will be used for calculations, so it is important to locate the photo gate in the right place.

7. Place the measuring tape on the floor for measuring the horizontal distance in which the ball lands from the edge of the table.

8. The ball's starting point is about 10 cm from the ruler's edge (between the 16 and 20 cm intervals of the lever ruler). The ruler's edge should be around 8 cm from the edge of the table.

9. Practice rolling the ball and tracking its horizontal distance from the edge of the table.

Sensor setup

10. Connect the USB-200 module to the PC.

11. Check that the photo gate sensor is connected to the USB-200 module.

Note:

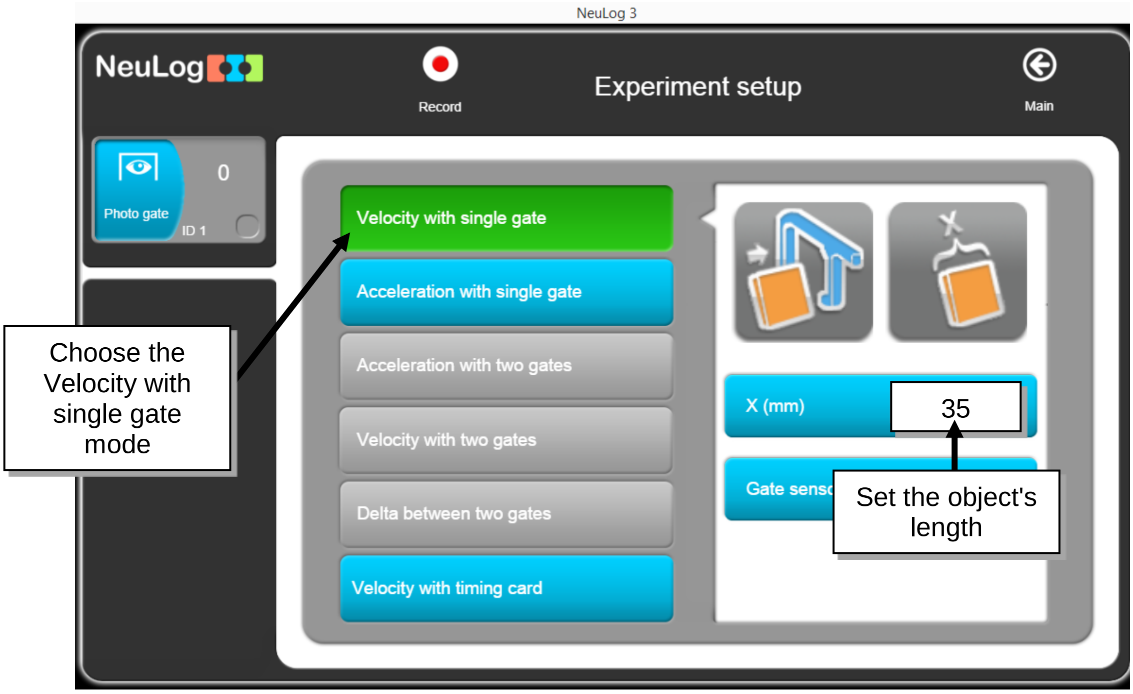
The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

12. Run the NeuLog application and check that the photo gate sensor is identified.

Settings

13. Click on the **Run experiment** icon  in the NeuLog main icon bar.

14. The following menu should appear. Set the configuration as explained below.

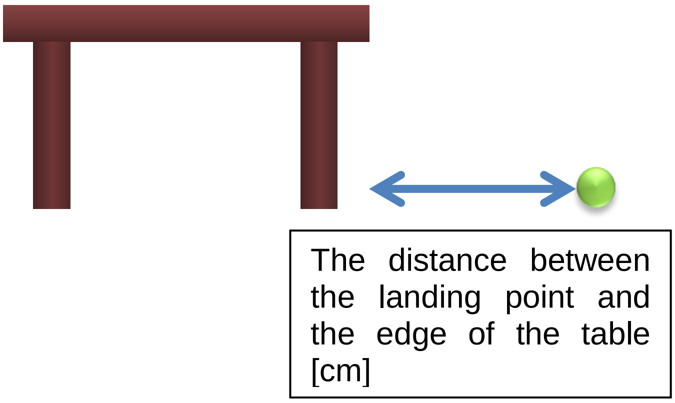


15. Insert the diameter of your ball in mm (3.5 cm = 35 mm).

Testing and measurements

16. Click on the **Record** icon  to start the measurement.

17. Roll the ball from the starting point without applying force on it. The purpose of the ramp is to release the ball from the table at a relatively fixed horizontal velocity. Look at the position in which the ball hit the ground and write it down in the following table.



	Distance between the landing point and the edge of the table [cm]	
Measurement number	Sample experiment	Student's experiment
1	12	
2	11	
3	10	
4	12	
5	11	
Average:	11.2 cm = **0.112 m**	

18. You will see a new time value on the screen for every measurement you make.

Time[sec] Avg :	0.2941	Velocity[m/s] Avg :	0.276 m/s
0.1212		0.2888	
0.1193		0.2934	
0.162		0.216	
0.1206		0.2902	
0.1202		0.2912	

19. Repeat this process four more times without stopping the experiment.

20. You will see the average velocity in the upper part of the table on your screen.

21. Click on the **Stop** icon  to stop recording data.

22. Click on the **Export** Icon  and then on the **Save value table (.CSV)** button to save your data.

23. Insert the average distance between the edge of the table and the landing point [cm] to the table above.

Calculations:

In order to calculate the predicted horizontal distance the ball passed, we need to know its velocity and the time it took for it to hit the ground.

Predicted distance = Measured Velocity × time

$$d(x) = v(x) \times t$$

Then we will compare these values to the measured distance value.

24. **The time it took for the ball to fall (for the sample experiment):**

    The following equation describes the time it took for an object to fall for a distance $d(y)$.

$$t = \sqrt{\frac{2d(y)}{g}} = \sqrt{\frac{2\times 0.74\ m(y)}{9.8\ m/s^2}} = 0.388\ s$$

    We know that the ball falls vertically according to the acceleration of gravity (9.8 m/s^2) without the effect of the horizontal motion.

    The height of the table is 74 cm = 0.74 m. Therefore, we can calculate the estimated time.

25. **Predicted distance (for the sample experiment):**

$$d(x) = v(x) \times t = 0.276\ \mathrm{m/s} \times 0.388\ \mathrm{s} = \mathbf{0.107\ m}$$

The ratio between the two distance values:

$$\frac{\boldsymbol{Measered\ d(x)}}{\boldsymbol{Predicted\ d(x)}} \times \mathbf{100}\%$$

0.112 m / 0.107 ×100% = 104.6%

We can see that the predicted and measured distance values are very close in the sample experiment.

26. Apply these calculations for your own measurements.

Challenge research

27. Put away the wooden box and ruler (or your ramp).

28. Click on the **Record** icon to start the measurement.

29. Apply force on the ball with your hand to roll it through the photo gate. Write down each one in the following table. Try to reach several different distances with the ball by rolling it with different velocities.

	$v(x)$ Measured horizontal velocity	t (The same for each measure ment) [s]	$Predicted\ d(x)$ The distance between the edge of the table and the landing point [m]	$Measured\ d(x)$ The distance between the edge of the table and the landing point [m]	Ratio: $\frac{Measered\ d(x)}{Predicted\ d(x)} \times 100\%$
1					
2					
3					
4					
5					

Summary questions

1. Explain the difference between the predicted distance values and the measured distance values you obtained in this experiment (in both parts).

2. If we would have conducted the experiment with a higher table, how would each parameter be affected? How would it affect the distance of the landing point and why?

3. A baseball is thrown 37 m/s horizontally and reaches the ground at a distance of 23 m from the pitcher. What is the height of the pitcher if he threw the ball right above his head?