Task outline:

Prior knowledge of projectile motion is required.

In this investigation, you are going to design an experiment to investigate projectile motion. You are required to study the relationship between the horizontal projection velocity (v_x) and the range of the projectile (horizontal displacement s_x). You should apply your knowledge and skills in Physics to solve the problems and draw conclusions based on the results obtained. Collaboration with your groupmates to complete the task is necessary.

The investigation is divided into five stages.

1. Searching for and defining questions for investigation
2. Developing an investigation plan
3. Conducting the investigation
4. Organizing and analyzing data for a justified conclusion
5. Presenting the investigation findings with a written report

Apparatus:

The following apparatus and materials will be provided:

- meter rule
- plastic sheet
- metal ball
- tape
- carbon paper
- clamp and stand

Students are recommended to propose other apparatus and materials that may be useful.

Discussion:

1. Propose the factors that can affect the range of a projectile. Are these factors changeable in the experiment? Identify the independent variables, dependent variables and control variables in your experiment.
2. Design a series of experiments in which you can check your hypotheses.
3. Carefully examine the feasibility and validity of your experiments.
4. Carry out a risk assessment to identify the safety precaution(s) needed to be taken.

Design of the experiment

1. Make an experiment setup for studying projectile motion
2. Change the initial conditions of the metal ball to control the projection speed

This part should be confirmed before the experiment. Comments will be given and your revised plan should be included in the report.

Implementation(实施情况)

1. Implementation of action plan with understanding
2. Proper use of apparatus
3. Proper experimental skills
4. Group work and time management
5. Ability to deal with problems encountered independently.

Questions may be asked during the experiment to verify understanding.

Report

1. Aim
2. Theory
3. Apparatus
4. Experiment Design and Procedure
5. Data presentation and graph plotting
6. Analysis and conclusion drawn according to experimental results
7. Record of reference materials

Investigating the relationship between horizontal projection velocity and the range of a projectile

Aim

To determine the relationship between the horizontal projection velocity *(v_x)* and the range of a projectile *(horizontal displacement, s_x)*.

Theory

The relationship between time(*t*), horizontal displacement(s_x), the vertical displacement(s_y), initial horizontal velocity(v_x) and initial vertical velocity(v_y) are shown below:

$$s_x = v_x t$$

$$s_y = v_y t + 1/2 \cdot g t^2$$

For a fixed projection angle θ to the horizontal ground and a fixed initial position (i.e. fixed s_y), the time of projection depends on v_y only. By setting the projection angle to 0 degree, the v_y can be reduced to 0. The formula becomes:

$$s_y = 1/2 \cdot g t^2$$

Where t becomes a constant as s_y and *g* are constants. Since a higher initial velocity (i.e., $v = v_x$) gives a longer range of a projectile(s_x).

Air resistance and friction between object and any surface are ignored.

Supporting theory: Conservation of mechanical energy

The law of conservation of mechanical energy states that the mechanical energy of an object cannot be created or destroyed. It can only be converted between kinetic energy and gravitational potential energy while experiencing no frictional force or air resistance. Hence, the initial horizontal velocity of the object in a projectile motion can be measured:

$$mgh = 1/2 \cdot m(v_x)^2$$

$$\therefore v_x = sqrt(2gh)$$

Apparatus

1. Meter rule
2. Metal ball
3. Plastic sheet
4. Tape
5. Clamp and stand

……

量角器 protractor
细线 thread/string
Carbon paper 碳纸
软尺 soft ruler

Experiment Design and Procedure

Factors affecting the range of a projectile:

1. Initial velocity (v_x)
2. Air resistance (neglected)
3. Height of the table (H)

Variables:

Independent: horizontal projection velocity (v_x)

Dependent: range of the projectile (s_x)

Control: mass of the projectile (M), height of table (H)…

Experiment Setup:

HERE SHOULD BE A DIAGRAM OF THE GRAPH

HERE SHOULD BE THE EXPLAINATION OF THE GRAPH

Data Presentation and Graph Plotting

Defining variables:

Height of the releasing position: h(cm) // angle of the meter ruler: ϕ (degree)

no. of exp	1	2	3	4	5	6
ϕ (d)						
h(cm)[=sqrt(2gh)]						
v_x(cm/s)						
s_x(cm)						

HERE SHOULD BE A GRAPH (ON GRAPH PAPER) OF S_X AGAINST V_X

Analysis and Conclusion

From the graph, it can be found that the graph of v_x against s_x is a straight line passing through the origin.

Further discussion

1. Does the experimental result consistent with your theory? If so, what is the slope of the line in the graph?

Yes. The hypothesis states that there is a linear relationship between s_x is directly proportional to v_x, and the straight line in the graph presents the same idea. The slope of the straight line in the graph is **CALCULATION**.

2.Express H in terms of t. Hence, calculate H.

CALCULATION

3. If a taller or shorter table is used instead, how will time vary? Hence, how will the range of projectile vary?

4. From the result obtained, it seems that the mass of the object does not affect the experiment result. Considering the vertical velocity of the object, briefly explain why.

5 In the experiment, any friction and air resistance are neglected. If the two forces cannot be neglected, explain how v_x and s_x may change.

Conclusion

The horizontal projection velocity *(v_x)* is directly proportional to the range of a projectile *(horizontal displacement, s_x)*.