

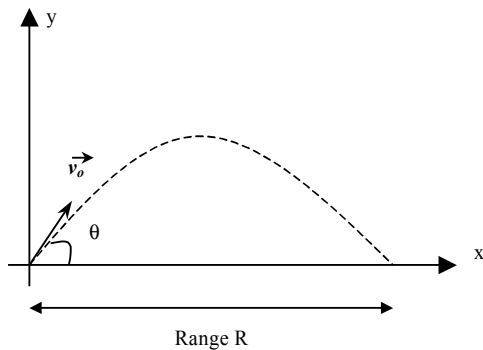
School: Baptist Lui Ming Choi Secondary SchoolClass: F. 6 ( ) Group ( )Name: ( )Subject: AL Practical PhysicsDate: Mark: 

## G 1 Projectile motion

### A. Objectives

- (1) To draw the trajectory of the projectile motion of a ball bearing;
- (2) To study the trajectories of projectile motions with different initial projected speed  $v_0$ ;
- (3) To find out the relation between the projecting angle  $\theta$  and the range  $R$  of a projectile motion at fixed  $v_0$  and determine the maximum range  $R_{\max}$  of the motion.

### B. Theory



Since the initial velocity  $\vec{v}_0$  is a vector, it can be resolved into two components. Write expressions for the vertical component  $v_{0y}$  and the horizontal component  $v_{0x}$  if the projecting angle is  $\theta$ .

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Which component is affected by gravity? Why?

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Let the starting point of the trajectory be the origin. Write equations for the vertical displacement  $y$  and the horizontal displacement  $x$  in terms of time  $t$ , taking  $t = 0$  when the ball bearing (marble) is at the origin. Remember that each component undergoes an **independent** motion.

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By eliminating  $t$  from the above equations, derive an expression for the trajectory of the projectile, i.e.  $y(x)$ .

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Also derive an expression for the range of the projectile in terms of  $v_0$  and  $\theta$ .

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For a fixed  $v_0$ , at what angle does R attains a maximum and what is its maximum value?

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Assume there is no energy loss due to friction and the ball bearing (marble) does not roll while it is flying. Calculate the numerical value of  $v_0$  when the ball bearing (marble) is released from the **height  $h = 55$  cm**.

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Hence calculate the maximum value of R.

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Plot the theoretical R against  $\theta$  on a graph paper. Label it clearly.

#### Theoretical data

Projecting angle $\theta / ^\circ$	25°	30°	35°	40°
Range R / m				
	45°	50°	55°	60°

#### C. Apparatus

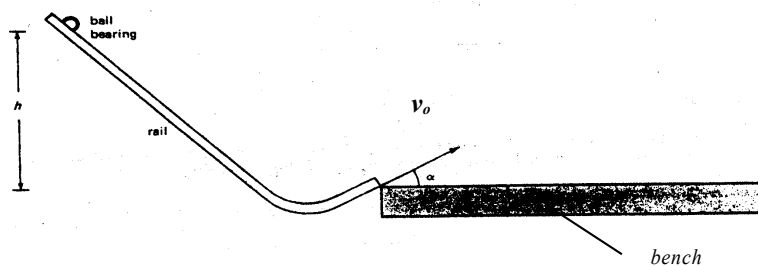
An H-shaped aluminum rail, bench, stand and clamp, meter rule, ball bearing, carbon paper, protractor, others upon request.

#### D. Method, Data and Data Analysis

An H-shaped aluminum rail ( $\sim 2$  m) is bent and fit to a long bench as shown in Fig. 1 so that the near end makes an angle  $\theta$  ( $\sim 30^\circ$ ) with the bench. A ball bearing (marble) on the rail is put at a height  $h$  ( $\sim 1$  m) above the bench.

#### **The trajectory**

The ball bearing (marble) is released so that it rolls down the rail and eventually projects onto the bench.



**Fig. 1**

**Draw in Fig. 1** the path of the ball bearing while it is flying.

The flying ball bearing is said to perform a projectile motion. The path that you have drawn is called the **trajectory** of the projectile. If  $y$  denotes the vertical displacement of the ball bearing (marble),  $x$  denotes its horizontal displacement, and  $t$  denotes the time elapsed, what does the **trajectory** represent - a  $y$ - $t$ ,  $x$ - $t$ , or  $y$ - $x$  graph?

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### Variation with $v_0$

By considering the conservation of energy, describe how the projecting velocity  $v_0$  of the ball bearing (marble) is affected by  $h$ .

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The ball bearing is released from various heights (keep the angle  $\theta$  constant). Describe the difference between trajectories for different projecting velocities.

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### Variation with $\theta$

The horizontal distance covered by the ball bearing when it reaches the bench is called the **range  $R$**  of the projectile. **Keeping  $h$  constant, measure the range  $R$  at various projecting angles  $\theta$ .**

Draw experimental setup in the below box in order to show how

- (1) the height  $h$  and the projecting angle  $\theta$  can be measured correctly,
- (2) the landing position of the ball bearing / marble can be marked;
- (3) the projecting angle is varied without any change in the height.

Set-up diagram

Describe how to minimize the random error in the measurement of the range.

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Tabulate your readings and plot a graph of R against  $\theta$  on the **same graph paper**. Label it as clearly.

**h = 55 cm**

Projecting angle $\theta / ^\circ$	25°	30°	35°	40°
Range R / m				
	45°	50°	55°	60°

Read from your graph the maximum value of R. \_\_\_\_\_

For what value of  $\theta$  is R a maximum? \_\_\_\_\_

**Compare** this calculated result with the experimental result. Account for any discrepancy.

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Plot also the examiner's R against  $\theta$  on the same graph paper. Label them clearly.

*Examiner's data*

Projecting angle $\theta / ^\circ$	25°	30°	35°	40°
Range R / m				
	45°	50°	55°	60°





