Projectile Motion

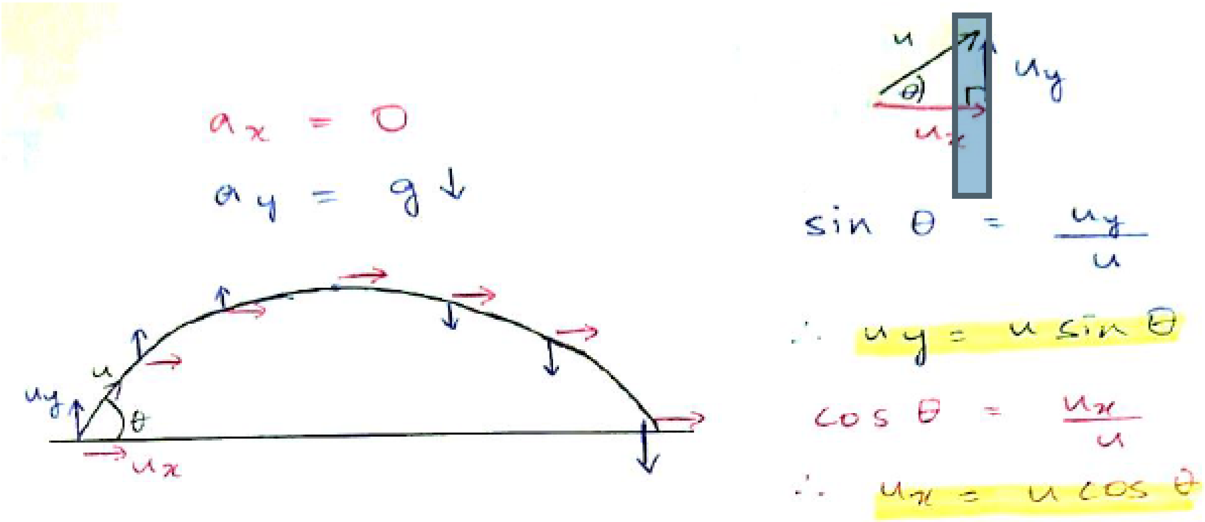
Inquiry question: How can models that are used to explain projectile motion be used to analyse and make predictions?

Students:

- *analyse the motion of projectiles by resolving the motion into horizontal and vertical components, making the following assumptions: a constant vertical acceleration due to gravity, zero air resistance*

NOTE: A projectile is an object travelling in air without any motive power. The only force acting on a projectile is the weight force due to gravity and there is no air friction or air lifting forces acting on a projectile. Examples of projectiles include a ball, bullet, cannon ball, javelin/spear.

Galileo's analysis of projectile motion:



1. Projectile motion consists of horizontal and vertical motion. Horizontal and vertical motion are independent
2. Horizontal motion is a constant velocity (0 acceleration). Vertical motion is the downward gravitational acceleration
3. The combination of the ball's motions forms a parabolic path

Equation of motion	Vertical motion (y)	Horizontal motion (x)
$v = u + at$	$v_y = u_y + a_y t$	$v_x = u_x$
$s = ut + \frac{1}{2}at^2$	$\Delta y = u_y t + \frac{1}{2}a_y t^2$	$\Delta x = u_x t$
$v^2 = u^2 + 2as$	$v_y^2 = u_y^2 + 2a_y \Delta y$	$v_x^2 = u_x^2$

• *apply the modelling of projectile motion to quantitatively derive the relationships between the following variables: initial velocity, launch angle, maximum height, time of flight, final velocity, launch height, horizontal range of the projectile (ACSPH099)*

Q1. A ball is thrown vertically up with an initial velocity of 30m/s. Find

a. Maximum height reached
b. Time taken to reach maximum height
c. Flying time
d. Final velocity after 4s

Q2. A stone is dropped from a cliff of height 150m. Find

a. Flying time
b. Final velocity just before hitting the ground
c. Velocity after 3s

***Solutions found at the end of this worksheet**

Highlighted Text below to be completed for Home Work

• *conduct a practical investigation to collect primary data in order to validate the relationships derived above.*

• *solve problems, create models and make quantitative predictions by applying the equations of motion relationships for uniformly accelerated and constant rectilinear motion*

SOLUTIONS

1a) $v_y^2 = u_y^2 + 2a_y\Delta y$

(+)↑ $0 = 30^2 + (2 \times -9.8 \times \Delta y)$

$-900 = -19.6\Delta y$

$\Delta y = 46m$

b) (+)↑ $v_y = u_y + a_y t$

$0 = 30 - 9.8t$

$t = 3.06s$

c) $t = 3.06 \times 2$

$= 6.12s$

d) $v_y = u_y + a_y t$

(+)↑ $v_y = 30 - 9.8 \times 4$

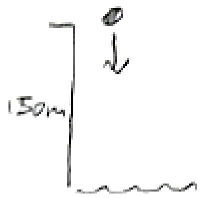
$= -9.2\ ms^{-1}$

$\therefore v_y = 9.2\ ms^{-1}$, downwards

2a) $\Delta y = u_y t + \frac{1}{2} a_y t$

(+)↓ $150 = 0 + (\frac{1}{2} \times 9.8 \times t^2)$

$t = 5.53s$



b) $v_y^2 = u_y^2 + 2a_y \Delta y$

(+)↓ $v_y^2 = 0 + (2 \times 9.8 \times 150)$

$v_y = 54.22ms^{-1}$

c) $v_y = u_y + a_y t$

(+)↓ $v_y = 0 + (9.8 \times 3)$

$v_y = 29.4\ ms^{-1}$, downwards