YEAR 12

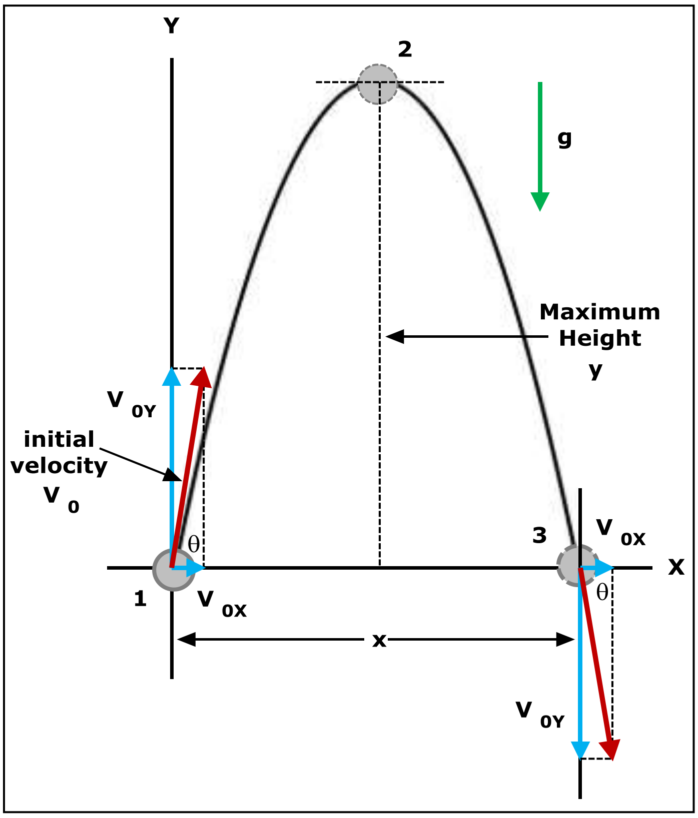
PHYSICS (STAGE 3)

PROJECTILE MOTION TEST

Student's Name:		Tutorial Group:	
Teacher's Name:		Date:	

- **Motion** is a continuous change in position. **Rectilinear motion** is motion in a straight line.
- The equations of rectilinear motion: $\mathbf{v = u + at}$; $\mathbf{v^2 = u^2 + 2as}$, and $\mathbf{s = ut + \frac{1}{2} a t^2}$
- **Projectile motion** is the motion of an object in a parabolic path near the Earth's surface under the action of gravity alone.

The Principles of Projectile motion



Galileo Galilei (1564 – 1642) argued that projectile motion was a **compound motion** made up of a **horizontal** and a **vertical** motion.

The adjacent diagram shows a projectile launched with an initial velocity of $\mathbf{V_0}$ at an angle of $\boldsymbol{\theta}^{\,0}$ to the horizontal.

The three principles of projectile motion can be stated as follows. The projectile:

- Has a horizontal velocity, which is constant.
- Has a vertical velocity, which is increasing downwards at $\mathbf{g = 9.8\ m\ s^{-2}}$.
- Follows a parabolic path (trajectory).

If air resistance can be ignored, the projectile motion can be analysed as two separate motions.

In a rectangular coordinate system, velocity $\mathbf{V_0}$ can be resolved into two vector components $\mathbf{V_{0Y}}$ and $\mathbf{V_{0X}}$ at $\mathbf{90^{0}}$ to each other.

When answering Questions 1 through 16, assume that air resistance is negligible, i.e., it can be neglected.

1. Can you draw an arrow, **on the Diagram on Page 1**, to show the velocity (magnitude and direction) of the projectile when it is located at Position 2 (at the top of its flight)? [**2 marks**]

2. During the projectile's flight, what is the **magnitude** of its acceleration in the **negative Y direction** shown in the Diagram given on Page 1?

[1 mark]

3. During the projectile's flight, what is the **magnitude** of its acceleration in the **X direction** shown in the Diagram given on Page 1?

[1 mark]

4. If it takes **t** seconds for the projectile to travel from Position 1 to Position 3, shown in the Diagram on Page 1, how many seconds will it take to travel from Position1 to Position 2?

[1 mark]

5. What is the mathematical equation for the **vertical component** $\mathbf{V_{0Y}}$ of the initial velocity $\mathbf{V_0}$?

[2 marks]

6. What is the mathematical equation for the **horizontal component** $\mathbf{V_{0X}}$ of the initial velocity $\mathbf{V_0}$?

[2 marks]

7. In the absence of air resistance, what single force acts on the projectile during its flight?

[1 mark]

8. In the absence of air resistance, why does the horizontal component $\mathbf{V_{0X}}$ **remain constant** during the flight of the projectile? To correctly answer this Question, you **must** apply this formula: $\mathbf{F = m \times a}$.

[3 marks]

9. What is the **acceleration** of the projectile when it is located at the top of its flight path (Position 2)?

[1 mark]

10. Why does the **vertical component** of $\mathbf{V_0}$: $\mathbf{V_{0Y} = 0}$**,** at the top of the projectile's flight path?

[3 marks]

The horizontal Range of a Projectile

- The **horizontal range R** of a projectile is the horizontal distance a projectile travels before it returns to its original height, which is typically the ground, i.e., $\mathbf{y\ (final) = y_0}$**.**

11. The horizontal range **R** is the distance between what **two positions** in the Diagram given on Page 1?

[2 marks]

12. By referring back to, and analysing the Diagram on Page 1, what mathematical equation can be used to calculate the constant horizontal speed $\mathbf{V_{0X}}$ of the projectile during its motion?

[2 marks]

13. If it takes **t** seconds for the projectile to reach its horizontal range **R**, while travelling at a constant horizontal speed $\mathbf{V_{0X}}$, what **mathematical equation** can be used to calculate the **magnitude** of **R**?

[2 marks]

TABLE 1: KINEMATIC EQUATIONS FOR PROJECTILE MOTION	
(y is taken as positive upward: $a_x = 0$; $a_y = -g = -9.80\ \mathrm{m\ s^{-2}}$)	
HORIZONTAL MOTION	VERTICAL MOTION *
($a_x = 0$; v_x = constant)	**($a_y = -g$ = constant)**
$v_x = v_{0x}$	$v_y = v_{0y} - g \times t$
$x = x_0 + v_{0x} \times t$	$y = y_0 + v_{0y} \times t - \frac{1}{2} g \times t^2$
	$v_y{}^2 = v_{0y}{}^2 - 2g\,(y - y_0)$
* If **y** is taken as positive downward, the minus (–) signs in front of **g** become plus (+) signs.	

You must answer Questions 14 and 15 in terms of the launch angle **θ** as given in the Diagram on Page 1.

14. What is the mathematical equation for the **vertical component** $\mathbf{V_{0Y}}$ of the initial velocity $\mathbf{V_0}$?

[2 marks]

15. What is the mathematical equation for the **horizontal component** $\mathbf{V_{0X}}$ of the initial velocity $\mathbf{V_0}$?

[2 marks]

Numerical Problem Solving

Babe Didrikson wins gold in 1932

Let's assume that Babe Didrikson's **43.68** m gold wining javelin throw, at the Olympics held in Los Angeles in 1932, had the following physical characteristics:

- Launch speed = **25.0** m s^{-1}
- Launch angle = **40.0** ^{0} to the ground
- Launch height = **2.00** m above the ground
- Air resistance was negligible

Quadratic formulae:

$$\mathbf{a x^2 + b x + c = 0}$$

$$\mathbf{x = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}}$$

16. Can you calculate the (a) size of the horizontal component; (b) size of the vertical component; (c) flight time; (d) height reached above the javelin's release point; (e) maximum height reached above the ground, and (f) horizontal range of the javelin?

Q16 (a) [2 marks]: (b) [2 marks]: (c) [4 marks]: (d) [2 marks]: (e) [1 mark], and (f) [2 marks]

[Total marks = 40]

Percent score =