

## Physics Math Test

### Projectile Motion in 2 Dimensions

1. Two balls A and B of masses 100 grams and 300 grams respectively are pushed horizontally from a table of height 3 meters. Ball A is pushed so that its initial velocity is 10 m/s and ball B is pushed so that its initial velocity is 15 m/s.

- a. Find the time it takes each ball to hit the ground.

The two balls are subject to the same gravitational acceleration and therefore will hit the ground at the same time.

$$\begin{array}{l} y = \frac{1}{2} a t^2 \\ 2 \cdot y = 2 \cdot \frac{1}{2} a t^2 \\ 2y = a t^2 \end{array} \quad \left| \begin{array}{l} \frac{2y}{a} = \frac{a t^2}{a} \\ \frac{2y}{a} = t^2 \\ \sqrt{\frac{2y}{a}} = \sqrt{t^2} \end{array} \right. \quad \left| \begin{array}{l} \sqrt{\frac{2y}{a}} = t \\ t = \sqrt{\frac{2y}{a}} \\ t = \sqrt{\frac{2 \cdot 3}{9.8}} = \sqrt{\frac{6}{9.8}} = 0.78 \text{ s} \end{array} \right.$$

- b. How far from the base of the table does each ball hit the ground?

$$X = v_x \cdot t$$

Ball A

$$X = 10 \text{ m/s} \cdot 0.78 \text{ s} = 7.8 \text{ m}$$

Ball B

$$X = 15 \text{ m/s} \cdot 0.78 \text{ s} = 11.7 \text{ m}$$

2. An arrow hits a target that is located 20 meters above and 60 meters away from its launching position. The arrow takes 4 seconds to reach the target.
- a. What is the initial horizontal velocity of the arrow?

$$V_x = \frac{x}{t}$$

$$V_x = \frac{60\text{m}}{4\text{s}} = 15\text{ m/s}$$

- b. What is the initial vertical velocity of the arrow?

~~$$y = V_y \cdot t - \frac{1}{2} g \cdot t^2$$~~

$$y = 20\text{ m}$$

$$t = 4\text{ s}$$

$$g = 9.8\text{ m/s}^2$$

$$V_y = ?$$

$$20 = V_y \cdot 4 - \frac{1}{2} \cdot 9.8 \cdot (4)^2$$

$$20 = 4V_y - \frac{1}{2} \cdot 9.8 \cdot 16$$

$$20 = 4V_y - 78.4$$

$$\begin{array}{r} 20 = 4V_y - 78.4 \\ +78.4 \quad \quad +78.4 \end{array}$$

$$\frac{98.4}{4} = \frac{4V_y}{4}$$

$$24.6 = V_y$$

$$V_y = 24.6\text{ m/s}$$

- c. What is the initial velocity of the arrow?

$$V_i = \sqrt{V_x^2 + V_y^2}$$

$$V_i = \sqrt{(15)^2 + (24.6)^2} = \sqrt{225 + 605.16} = \sqrt{830.16}$$

$$V_i = 28.8\text{ m/s}$$