NAME ____________ DATE ____________ CLASS ____________

Two-Dimensional Motion and Vectors

Problem D

PROJECTILES LAUNCHED HORIZONTALLY

PROBLEM

A movie director is shooting a scene that involves dropping s stunt dummy out of an airplane and into a swimming pool. The plane is 10.0 m above the ground, traveling at a velocity of 22.5 m/s in the positive *x* direction. The director wants to know where in the plane's path the dummy should be dropped so that it will land in the pool. What is the dummy's horizontal displacement?

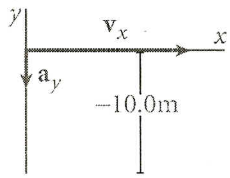
SOLUTION

1. DEFINE

Given: $\Delta y = -10.0\ \text{m}$ $\quad a_y = -g = -9.81\ \text{m/s}^2$ $\quad v_x = 22.5\ \text{m/s}$

Unknown: $\Delta t = ?$ $\quad \Delta x = ?$

Diagram: The initial velocity vector of the stunt dummy only has a horizontal component. Choose the coordinate system oriented so that the positive *y* direction points upward and the positive *x* direction points to the right.



2. PLAN

Choose the equation(s) or situation: The dummy drops with no initial vertical velocity. Because air resistance is neglected, the dummy's horizontal velocity remains constant.

$$\Delta y = \frac{1}{2} a_y (\Delta t)^2$$

$$\Delta x = v_x \Delta t$$

Rearrange the equation(s) to isolate the unknown(s):

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}}$$

3. CALCULATE

First find the time it takes for the dummy to reach the ground.

$$\Delta t = \sqrt{\frac{(2)(-10.0\text{m})}{(-9.81\ \text{m/s}^2)}} = 1.43\ \text{s}$$

Find out how far horizontally the dummy can travel during this period of time.

$$\Delta x = v_x \Delta t = (22.5\ \text{m/s})(1.43\ \text{s})$$

$$= \boxed{32.2\ \text{m}}$$

4. EVALUATE

The stunt dummy will have to drop from the plane when the plane is at a horizontal distance of 32.2 m from the pool. The distance is within the correct order of magnitude, given the other values in this problem.

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D Launched horizontally

ADDITIONAL PRACTICE

1. Florence Griffith-Joyner of the United States set the women's world record for the 200 m run by running with an average speed of 9.37 m/s. Suppose Griffith-Joyner wants to jump over a river. She runs horizontally from the river's higher bank at 9.37 m/s and lands on the edge of the opposite bank. If the difference in height between the two banks is 2.00 m, how wide is the river?

2. The longest banana split ever made was 7.320 km long (needless to say, more than one banana was used). If an archer were to shoot an arrow horizontally from the top of Mount Everest, which is located 8848 m above sea level, would the arrow's horizontal displacement be larger than 7.32 km? Assume that the arrow cannot be shot faster than 100.0 m/s, that there is no air resistance, and that the arrow lands at sea level.

3. The longest shot on a golf tournament was made by Mike Austin in 1974. The ball went a distance of 471 m. Suppose the ball was shot horizontally off a cliff at 80.0 m/s. Calculate the height of the cliff.

4. Recall Elmer Trett, who in 1994 reached a speed of 372 km/h on his motorcycle. Suppose Trett drives off a horizontal ramp at this speed and lands a horizontal distance of 40.0 m away from the edge of the ramp. What is the height of the ramp? Neglect air resistance.

5. A Snorkel fire engine is designed for putting out fires that are well above street level. The engine has a hydraulic lift that lifts the firefighter and a system that delivers pressurized water to the firefighter. Suppose that the engine cannot move closer than 25 m to a building that has a fire on its sixth floor, which is 25 m above street level. Also assume that the water nozzle is stuck in the horizontal position (an improbable situation). If the horizontal speed of the water emerging from the hose is 15 m/s, how high above the street must the firefighter be lifted in order for the water to reach the fire?

6. The longest stuffed toy ever manufactured is a 420 m snake made by Norwegian children. Suppose a projectile is thrown horizontally from a height half as long as the snake and the projectile's horizontal displacement is as long as the snake. What would be the projectile's initial speed?

7. Libyan basketball player Suleiman Nashnush was the tallest basketball player ever. His height was 2.45 m. Suppose Nashnush throws a basketball horizontally from a level equal to the top of his head. If the speed of the basketball is 12.0 m/s when it lands, what was the ball's initial speed? (Hint: Consider the components of final velocity.)

8. The world's largest flowerpot is 1.95 m high. If you were to jump horizontally from the top edge of this flowerpot at a speed of 3.0 m/s, what would your landing velocity be?

Additional Practice D

Projectiles Launched Horizontally

1) **X**

$V = 9.3\,m/s$

$t = .63$

$d = 5.98$

Y

$d = -2.0\,m$

$a = -9.81\,m/s^2$

$t = .63$

$y = \frac{1}{2}at^2$ (2)

$\sqrt{\frac{-2}{4.9}} = t$

$t = .63$

$d = Vt = \boxed{5.98\,m}$

2) **X**

4250 m

$d = 7320\,m$

$t = 42.5\,s$

100 m/s

$V = \boxed{172\,m/s}$

Y

$d = -8848\,m$

$a = -9.81\,m/s^2$

$t = 42.5\,s$

$\sqrt{\frac{8848}{4.9}} = 42.5\,s$

$V = \frac{d}{t} = \frac{7320}{42.5} = 100 = \frac{x}{42.5}$

$4250\,m = x$

NO, the arrow can only go 100 m/s but needs to go 172 m/s.

3) **X**

$d = 471\,m$

$V = 80\,m/s$

$t = 6.0\,s$

Y

$a = -9.8\,m/s^2$

$d = x$

$t = 6.0\,s$

$a = \frac{V_f - V_i}{t}$

$V = \frac{d}{t}$

$y = \frac{1}{2}at^2$

$y = \frac{1}{2}(9.81)\,6.0^2$

$\boxed{= -170\,m}$

$V = \frac{d}{t}$ $t = \frac{d}{V}$

$t = \frac{471}{80}$

$t =$

4) X　　　　　Y

$V = 372\ km/h$ (103 m/s)　　$a = -9.81\ m/s^2$

$d = 40m$　　$d = x$

$t = .39s$　　$t = .39s$

$V = \frac{d}{t}$

$t = \frac{d}{V} = \frac{40}{103} = .39s$

$d_y = \frac{1}{2}at^2$

$= \frac{1}{2}(9.81)(.39s^2)$

$d_y =$ .74m above the ground

5) X　　　　　Y

$d = 25m$　　$d = X$

$V = 15\ m/s$　　$a = -9.81$

$t = 1.67s$

$t = \frac{d}{V} = \frac{25}{15} = 1.67s$

$d = \frac{1}{2}at^2$

$= \frac{1}{2}(9.81)1.67^2$

$d = 13.63m + 25m = 39m$

↓ bldg.

6) X　　　　　Y

$d = 420m$　　$d = 210m$

$t = 6.55s$　　$a = -9.81$

$V = 64\ m/s$　　$t = 6.55s$

$V = \frac{d}{t} = \frac{420}{6.55} = 64\ m/s$

$t = \sqrt{\frac{d}{\frac{1}{2}a}} = \frac{210}{4.9}$

~~$\frac{V_f + V_i}{2}$~~ $= \frac{d}{t}$　　$a = \frac{V_f - V_i}{t}$

$V_i = 0$ for vertical

$d = V_i \Delta t + \frac{1}{2}at^2$

7) X　　　　　Y

$d = 2.45m$　　$d = 2.45m$

$V_f = 12\ m/s$

$V_i =$

$a = -9.81\ m/s^2$

$V_f^2 = 2ad + V_i^2$

$12\ m/s = 2(-9.81)(-2.45) + V_i^2$

48

$\sqrt{12^2 - 48}$

$\sqrt{144 - 48}$

$V_i = 9.8\ m/s$

8) X　　　　　Y

$V = 3\ m/s$　　$d = 1.95m$

$V_f = X$

$t =$

$a = -9.81\ m/s^2$

$V_f^2 = 2ad + V_i^2$

$V_f^2 = 2(-9.81)(-1.95) + 3^2$

$V_f = \sqrt{38.26 + 9}$

6.88 m/s

#7

X

$V = \frac{d}{t}$

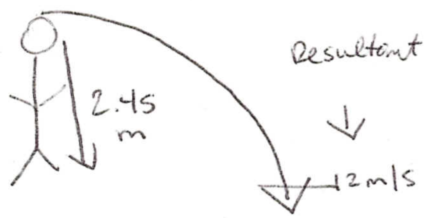
Y

$d = V_i t + \frac{1}{2} a t^2$

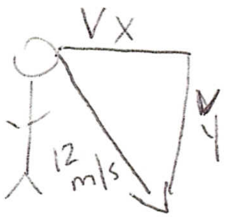
$d = 2.45\,m$

$V_f = 12\,m/s$

$a = -9.81\,m/s^2$



b/c 12 m/s is the resultant



=

$V_f^2 = V_{fx}^2 + V_{fy}^2$

$12^2 = V_{fx}^2 + V_{fy}^2$

$V_i = 0$

$V_{fy}^2 = 2ad + V_{iy}^2$

$a = \frac{V_f - V_i}{t}$

$t = \frac{V_f - V_i}{a}$

$\frac{V_f + V_i}{2} = \frac{d}{\frac{V_f - V_i}{a}}$

$V_{fy}^2 = 2ad + V_{iy}^2$

$144 = V_x^2 + 2(a)(d)$ m^2/s^2

$m/s^2 \cdot m$

$V_x^2 = 144 - 2(9.81)(2.45)$

$V_x = \sqrt{144 - 48.1}$

$V_x = 9.79\,m/s$