Solving Horizontal Projectile Problems

Objects that are launched into the air and travel both horizontally and vertically are called projectiles. Situations like this involve using information from both vertical motion (y) and horizontal motion (x) to solve problems. There are some steps that can be followed to help you guide yourself to the answers you require, and some hints given in the problems that can help you start.

In each dimension, x and y, you will need to know the same six quantities that we used in one dimensional motion; initial and final velocity, initial and final position, acceleration and time. (vo, vf, x, xo, a, t)

If the problem says something about an object moving **horizontally** then initially it only has velocity in the x direction (vox) and it has initial y velocity of zero, (voy). Other information that will always be the same for projectiles: **Vertical acceleration will always be – 9.8 (downward) when an object is flying through the air. Horizontal acceleration will always be ZERO.** (This means that the horizontal velocity will NEVER change, vox = vfx)

The one quantity that both the horizontal and vertical motion have in common is **time**. The object will move in the x direction for the same amount of time as it will fall in the y direction. This means that if you are given the **height** of a horizontally launched projectile you can determine the amount of time the object will be moving using the position time equation, y = yo + voyt+1/2 at2.

The initial vertical velocity is ZERO so you end up with **h = ½ at2**

If you are not given height, then you should be given information in the problem to find time from the horizontal dimension. The object moves at constant velocity in the horizontal, x, direction and the only equation that applies to that situation is

v = Δx/t; variations of this are (v)(t) = x and t = x/v

Two problems below illustrate these time concepts.

Ex 1: Height is given:

An object is launched horizontally from a tower 15 m high with a velocity of 25 m/s. You could be asked to find several things about this object, but commonly the question will be to find out haw far it travels before hitting the ground (the range of the projectile). You could also be asked to find out its final vertical velocity, (vfy), or final net velocity (the resultant of the vfx and vfy). ***The first thing you have to do after you list everything you know for both dimensions is determine the time the object will be in the air.***

Vertical Horizontal

yo (height) 15 m xo = 0 (Almost every time)

voy  0 m/svox 25 m/s (given)

a - 9.8 m/s/s **(always)** a = 0 **(every time)**

t ?? t ??

vfy ?? vfx = 25 m/s (a = 0, vox = vfx)

y 0 x ??

To find time when given height, h = ½ at2 ; 15 = ½ (9.8)t2 = [(2x15)/9.8]1/2

(Square root of 2h/a). Here it equals 1.75 s. That’s the time it will take to fall and that’s the time it will move in the x direction. NOW you can use that time to find out how far the object will fly using x = v t; x = (25 m/s)(1.75 s) = 43.8 m

You could also use the time to find out how fast its moving vertically when it hits the ground, vf = vo + at = 0 + (- 9.8)(1.75) = - 17.2 m/s

Ex 2 Launch from an unknown height

An object is thrown horizontally from a tower with a velocity of 15 m/s and lands 25 m from the base of the tower. Look at the same initial data

Vertical Horizontal

yo = ?? xo = 0 (Almost every time)

voy  0 m/svox 15 m/s (given)

a - 9.8 m/s2 **(always)** a = 0 **(every time)**

t ?? t ??

vfy ?? vfx = 15 m/s (a = 0, vox = vfx)

y 0 x = 25 m

No height is given, so you must find time from the horizontal motion

x = vt so t = x/v 25 m/15 m/s = 1.66 s. You can use this time now to find out anything else you need to know like the height of the tower.

Height is vertical so h = ½ at2 ; h = ½ (9.8m/s2 )(1.66s)2 = 13.5 m

Final vertical velocity: vf = vo + at = 0 + (-9.8m/s2)(1.66) = - 16.3 m/s

Practice Problems:

 A ball is thrown horizontally from a window 13 m above the ground with a velocity of 18 m/s. How far will the ball fly horizontally before it lands on the level ground below?

List the vertical and horizontal quantities you know in the table below

|  |  |
| --- | --- |
| Vertical | Horizontal |
| yo =  | xo = 0 (almost always) |
| voy = 0 (horiz launch) | vox =  |
| a = -9.8 m/s2 (always) | a= 0 (always) |
| t = ? | t = ? |
| vfy = ?  | vfx = (a = 0)  |
| y = 0  | x = ? |

It is not stated here to find time, but you must find time before anything else can be done. Find the time the ball is in the air. (1.63 s)

Find the distance the ball will fly ((29.3 m)

Find the final vertical velocity of the ball (- 16.0 m/s)

An arrow is shot horizontally from a tower with a velocity of 45 m/s and lands 115 m from the base of the tower. Determine the height of the tower? (Again, you’re not told to find time, but you must.)

|  |  |
| --- | --- |
| Vertical | Horizontal |
| yo =  | xo = 0 (almost always) |
| voy = 0 (horiz launch) | vox =  |
| a = -9.8 m/s2 (always) | a= 0 (always) |
| t =  | t =  |
| vfy =  | vfx = (a = 0) |
| y = 0  | x =  |

Find the time the arrow is in the air. (2.56 s)

Find the height of the tower (32 .1 m)

A projectile is launched horizontally off a table top that is 1.35 m above the floor and lands a horizontal distance of 0.92 m from the bottom of the table. Determine the initial horizontal velocity of the projectile.

|  |  |
| --- | --- |
| Vertical | Horizontal |
| yo =  | xo = 0 (almost always) |
| voy = 0 (horiz launch) | vox =  |
| a = -9.8 m/s2 (always) | a= 0 (always) |
| t =  | t =  |
| vfy =  | vfx = (a = 0) |
| y = 0  | x =  |

Fill in the table with the information you know. Find the time, (0.524 s) then find the initial velocity (1.75 m/s).