Projectile Motion

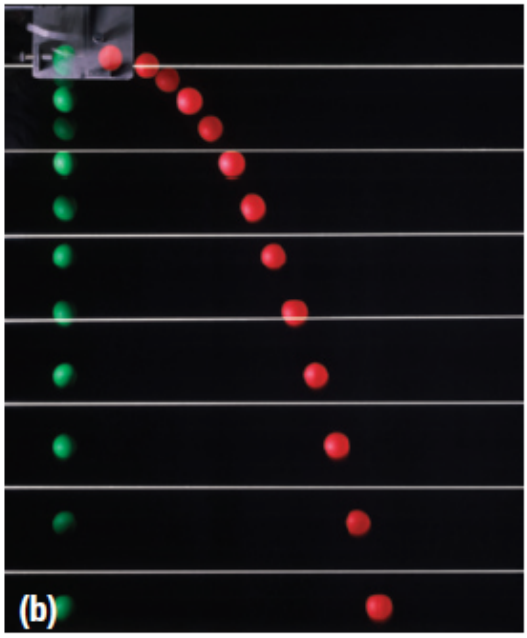
Any object that moves in response to **gravity** along a two-dimensional curved trajectory is called a projectile. The motion of a projectile under gravity is called projectile motion.

Learning Goal: By the end of this section, I will be able to calculate the range, max height, time of flight, etc. for projectile motion.

Sep 25-11:18 AM

Time Lapse Image of a Rubber Ball being dropped and one being projected.

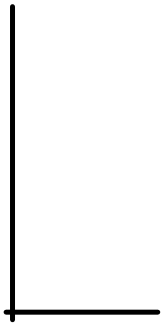
What similarities and differences can you see?

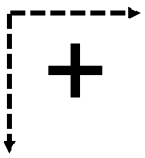


What would a motion diagram for each position component of the red ball look like?

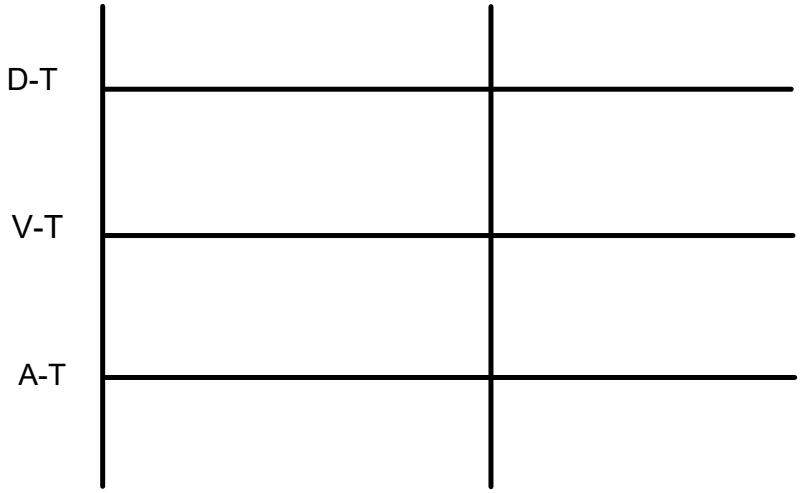
X component

Y component





Motion Graphs



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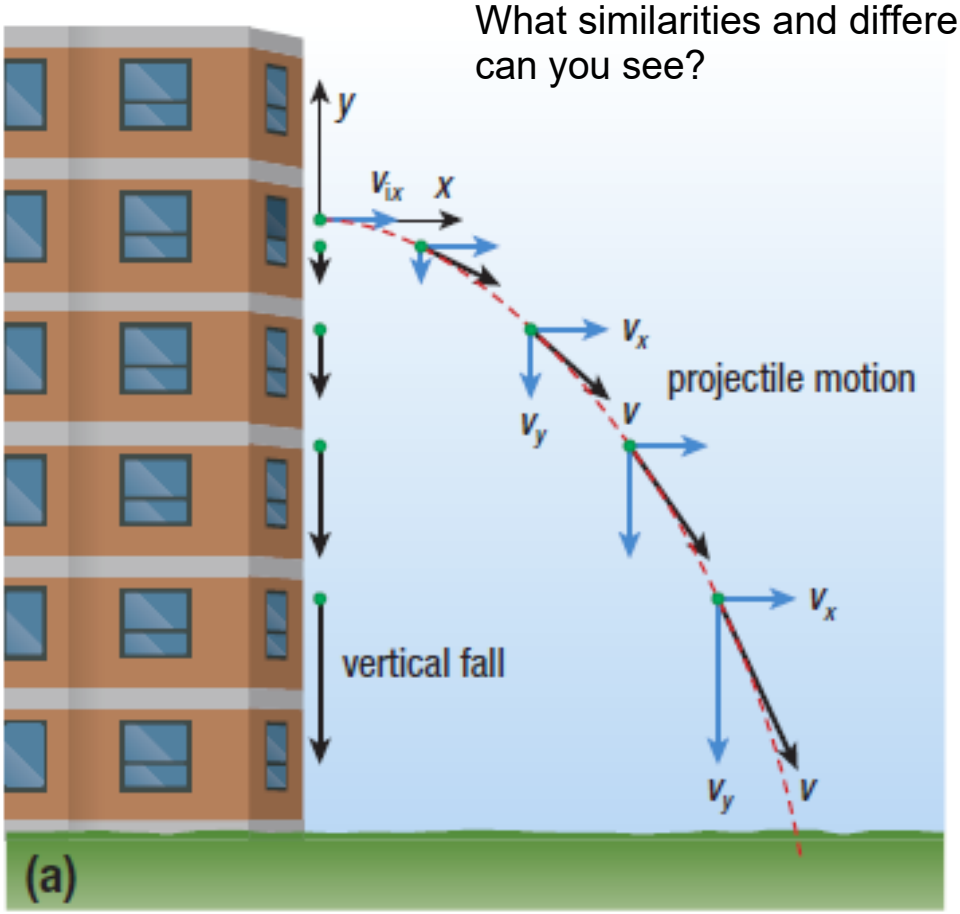
Vector Representation of Projectile Motion

What similarities and differences can you see?



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In projectile motion, once the object is "launched/projected" there is only on exterior acceleration taking place, and that is the acceleration due to gravity We ignore air resistance at this point in time.

This means that the horizontal velocity NEVER changes, while the vertical velocity experiences the effects of gravity, similar to the one dimensional problems discussed in Chapter One.

In two dimensional motion, we now have to indicate whether an object's velocity is Horizontal or Vertical, this can be done using subscripts.

Vertical Notations

V_{yi} V_{yf} V_{Vi} V_{Vf}

Horizontal Notations

V_{xi} V_{xf} V_{Hi} V_{Hf}

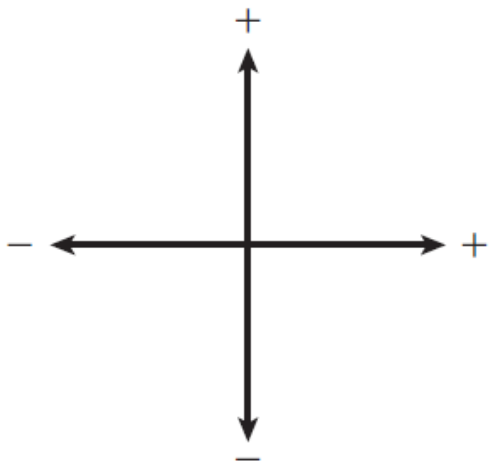

Figure 3 Sign conventions for projectile motion

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Sample Problem 1

A beanbag is thrown from a window 10.0 m above the ground with an initial horizontal velocity of 3.0 m/s.

(a) How long will it take the beanbag to reach the ground? That is, what is its time of flight?

(b) How far will the beanbag travel horizontally? That is, what is its range?

Given:

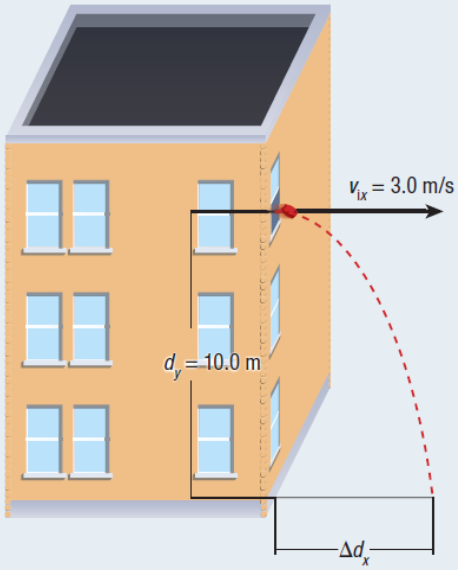


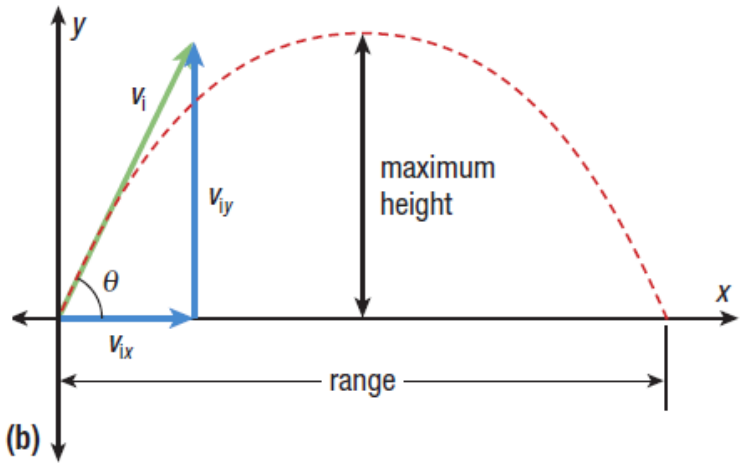
Figure 4 Projectile motion, launching horizontally

Projectiles can be launched at angles measured to the horizontal.

By changing the angle you can control the horizontal and vertical distance travelled by the projected object.

As we did with the displacement vectors, we can resolve or break up the given velocity into its horizontal and vertical components.

Many flash video games are a variation of this concept.



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Sample Problem 1

A soccer player running on a level playing field kicks a soccer ball with a velocity of 9.4 m/s at an angle of 40° above the horizontal. Determine the soccer ball's

(a) time of flight

(b) range

(c) maximum height

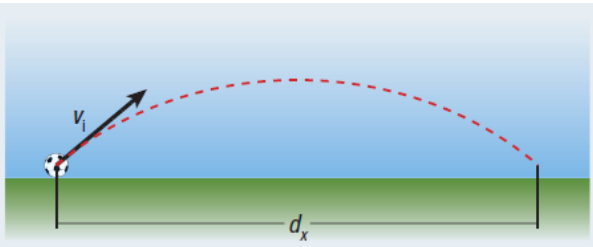

Figure 6 Motion of the soccer ball

Given Information:

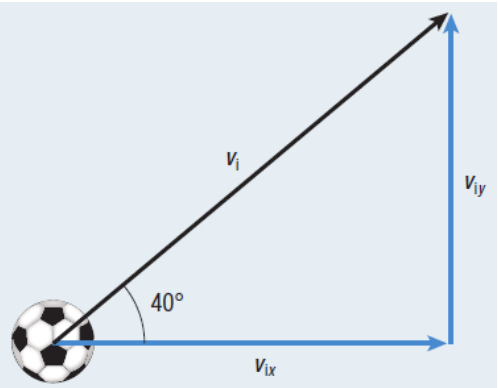

Figure 7 Components of the initial velocity

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Sample Problem 2

A golfer is trying to improve the range of her shot. To do so she drives a golf ball from the top of a steep cliff, 30.0 m above the ground where the ball will land. If the ball has an initial velocity of 25 m/s and is launched at an angle of 50° above the horizontal, determine the ball's time of flight, its range, and its final velocity just before it hits the ground. **Figure 8** shows the motion of the golf ball.

For this solution we will combine the horizontal and vertical given statements.

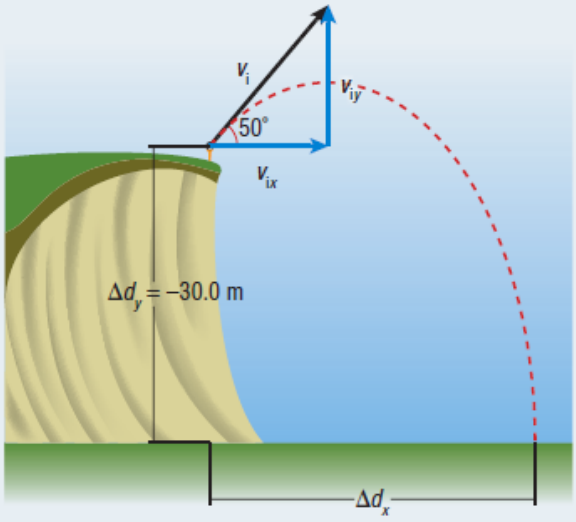

Figure 8 Motion of the golf ball

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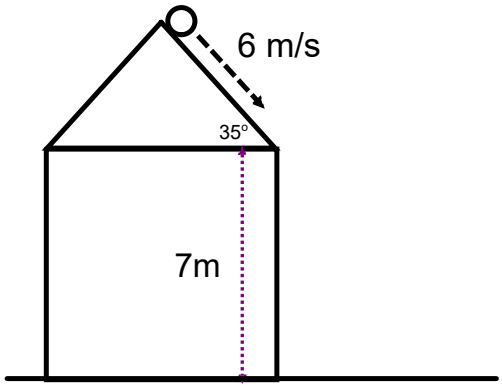
A ball rolls down the roof of a house.

The ball has an initial velocity of 6m/s when it clears the roof.

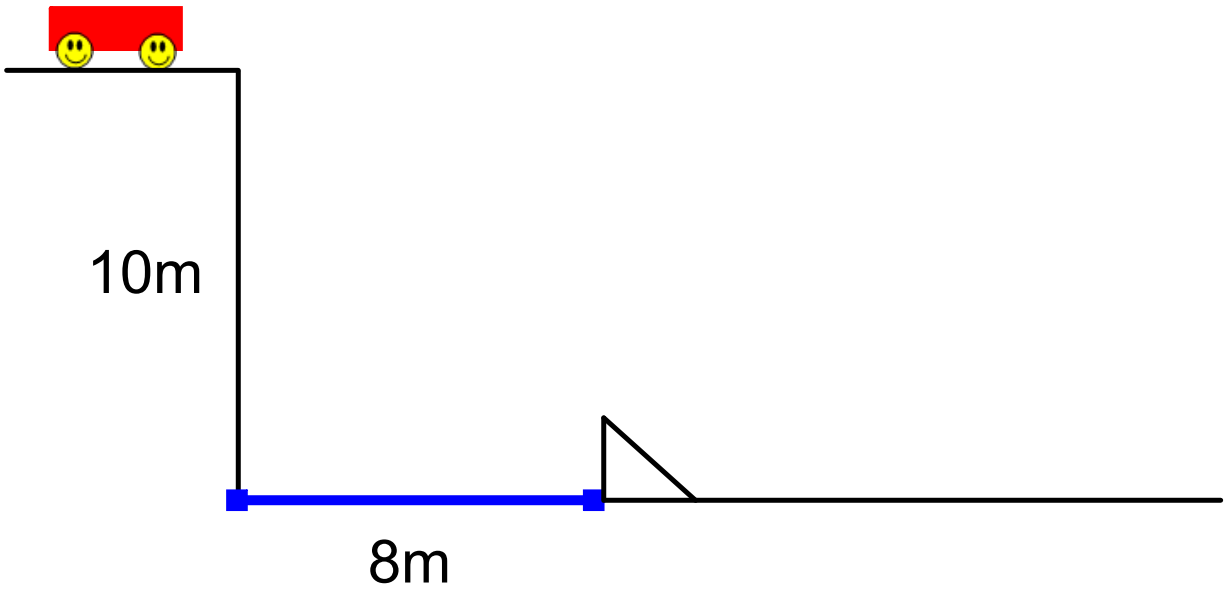
How long is the ball in the air?

How far from the base of the house does it land?



Feb 6-10:24 PM

A stunt driver is going to drive off a cliff, over a river and land on the far side. At what velocity must he drive off the cliff at to clear the river safely? What angle is required for the landing ramp on the far side.



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A mountain biker can reach a maximum speed of 16m/s for a short sprint. She is planning to perform a cool trick for her friends where she takes a jump and lands on top of a 4m tall building. At what angle should she build the jump to accomplish this task? and how far from the building should the jump be?

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Homework

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