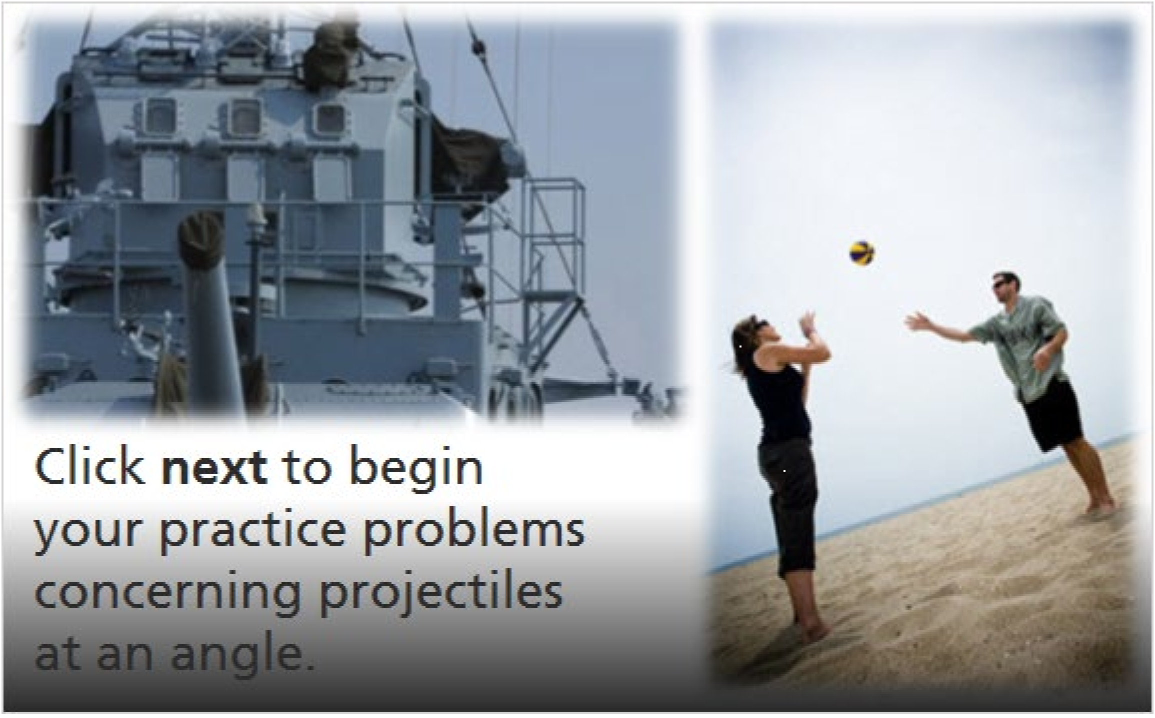
Module 3: Motion in Two Dimensions
Topic 3 Content: Projectiles at an Angle Practice Solutions



Click next to begin your practice problems concerning projectiles at an angle.

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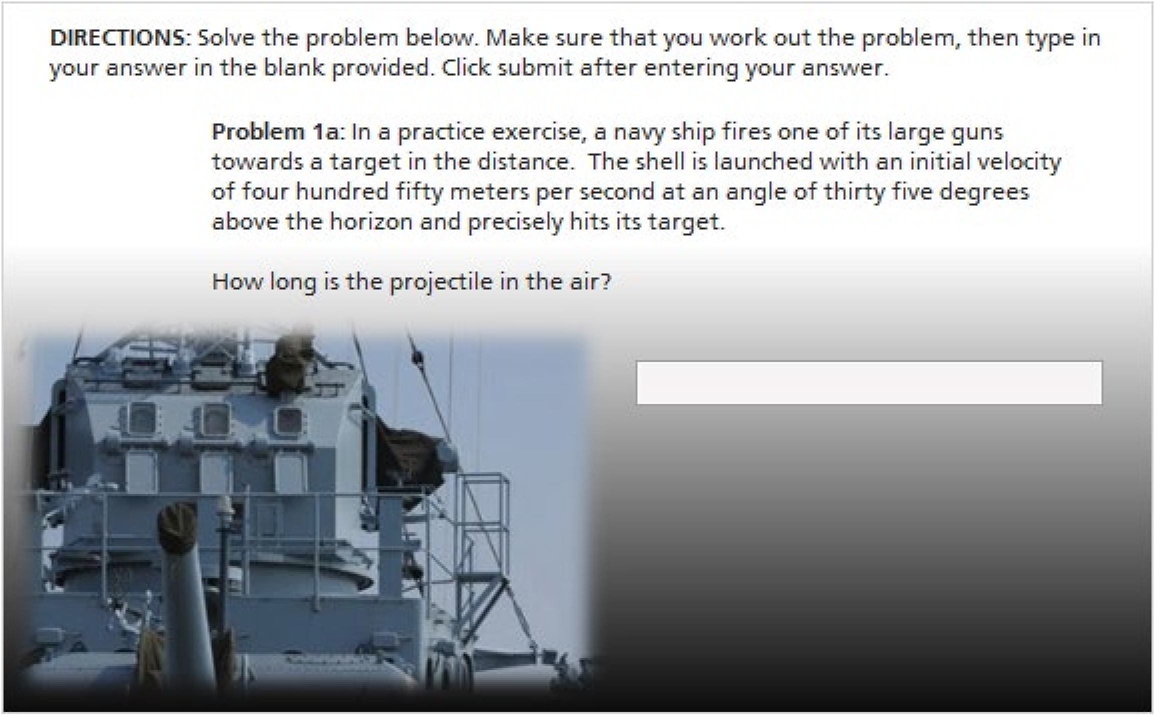
Problem 1a



In a practice exercise, a navy ship fires one of its large guns towards a target in the distance. The shell is launched with an initial velocity of four hundred fifty meters per second at an angle of thirty five degrees above the horizon and precisely hits its target. How long is the projectile in the air?

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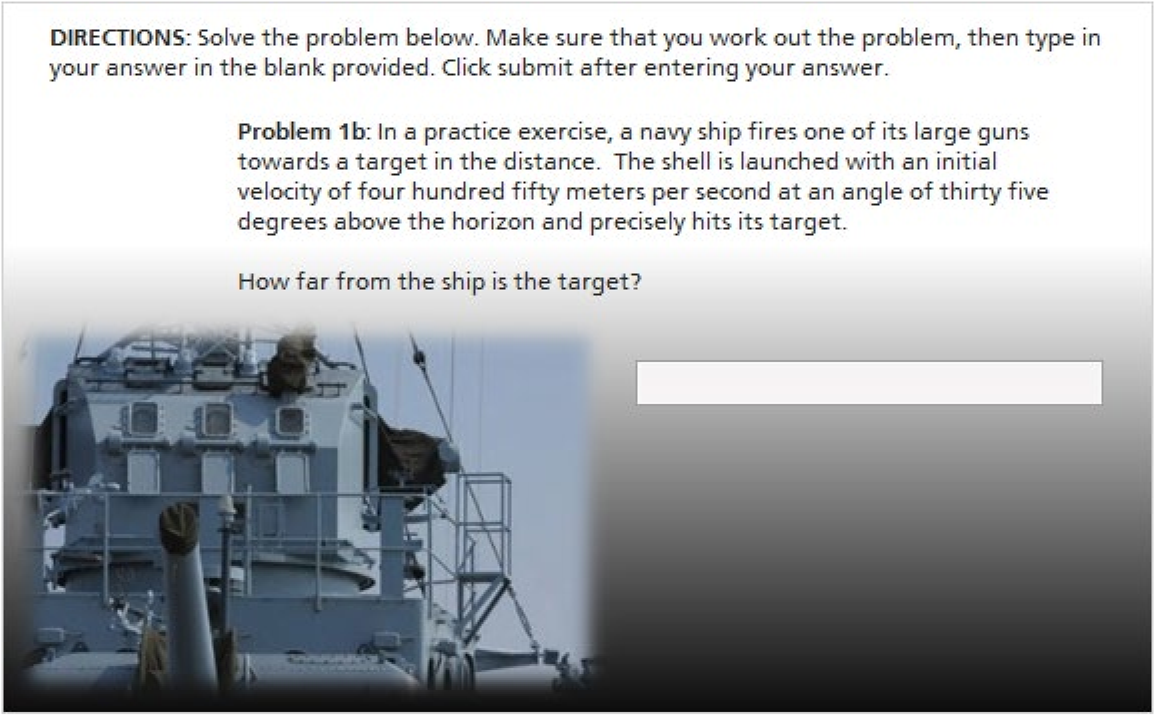
Problem 1b



In a practice exercise, a navy ship fires one of its large guns towards a target in the distance. The shell is launched with an initial velocity of four hundred fifty meters per second at an angle of thirty five degrees above the horizon and precisely hits its target. How far from the ship is the target?

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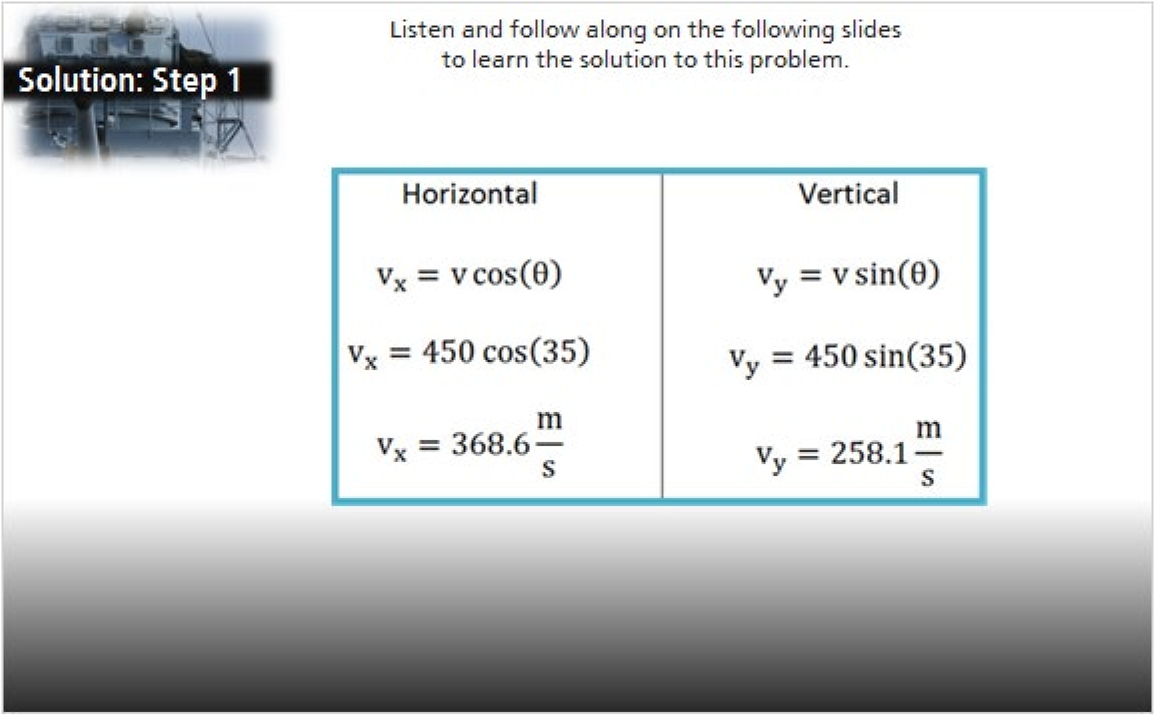
Problem 1 Solution Step 1



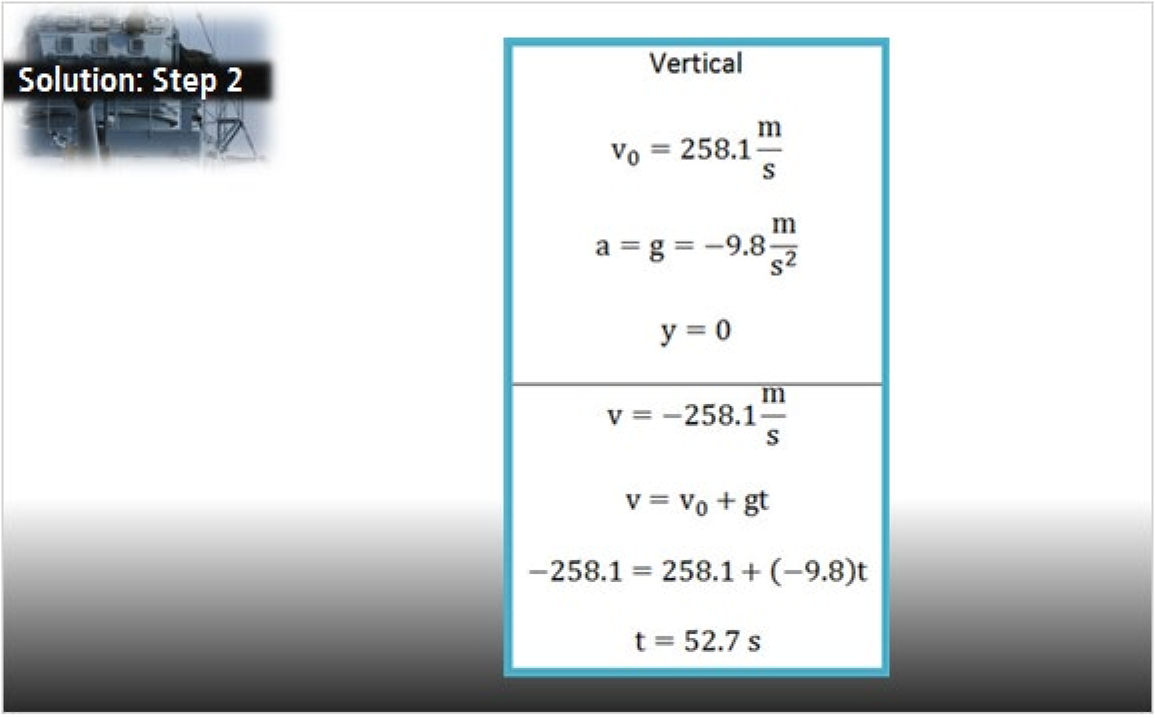
Again, the best way to start any projectile motion problem is to identify the horizontal and vertical variables. We don't know the time or the displacement in the horizontal direction, but we can determine the horizontal component of the velocity.

The horizontal component of the velocity is equal to the actual velocity times the cosine of the angle with the horizontal.

Similarly, the vertical component of the velocity is equal to the velocity times the sine of the angle above the horizontal.

Substituting and solving, we see that the shell has an initial horizontal velocity of three hundred sixty eight point six meters per second and an initial vertical velocity of two hundred fifty eight point one meters per second.

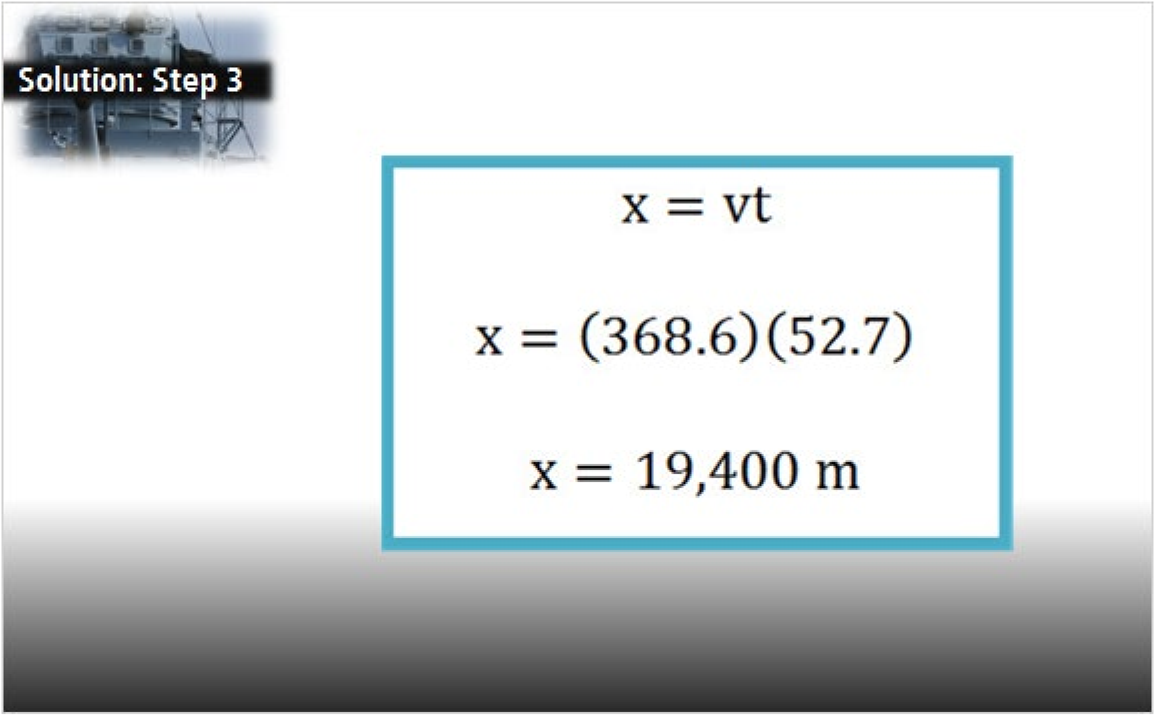
Problem 1 Solution Step 2



The y component of the initial velocity is the initial y velocity. Also in the vertical direction, we know the gravitational acceleration of nine point eight meters per second squared in a negative direction. The vertical displacement is zero since the shell rises and falls back to its initial height.

We also know that since the shell returns to the same height, that the final vertical velocity is the opposite of the initial vertical velocity. With an initial vertical velocity, and a final vertical velocity and an acceleration, we can determine the time of flight. Substituting and solving, we see that the time of flight is fifty two point seven seconds.

Problem 1 Solution Step 3

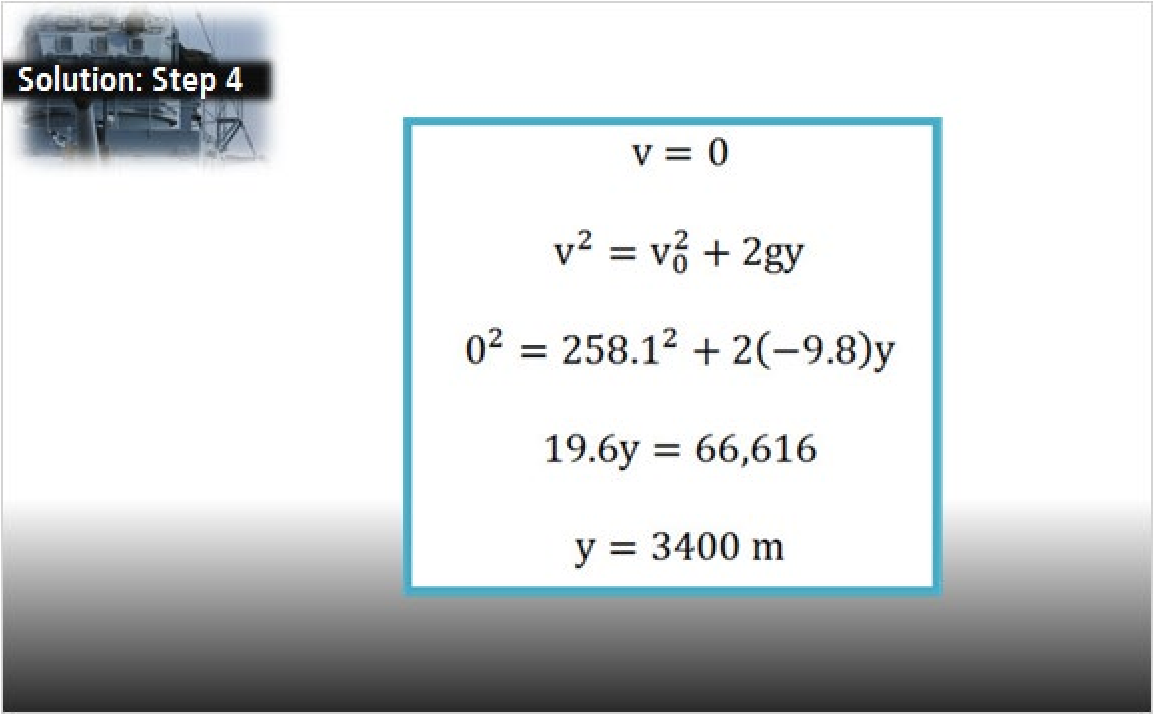


Now we can determine the horizontal distance to the target. The horizontal displacement equals the horizontal velocity times the time.

Substituting and solving, we see that the horizontal range is nineteen point four kilometers.

In the previous question, what was the maximum height achieved by the shell?

Problem 1 Solution Step 4

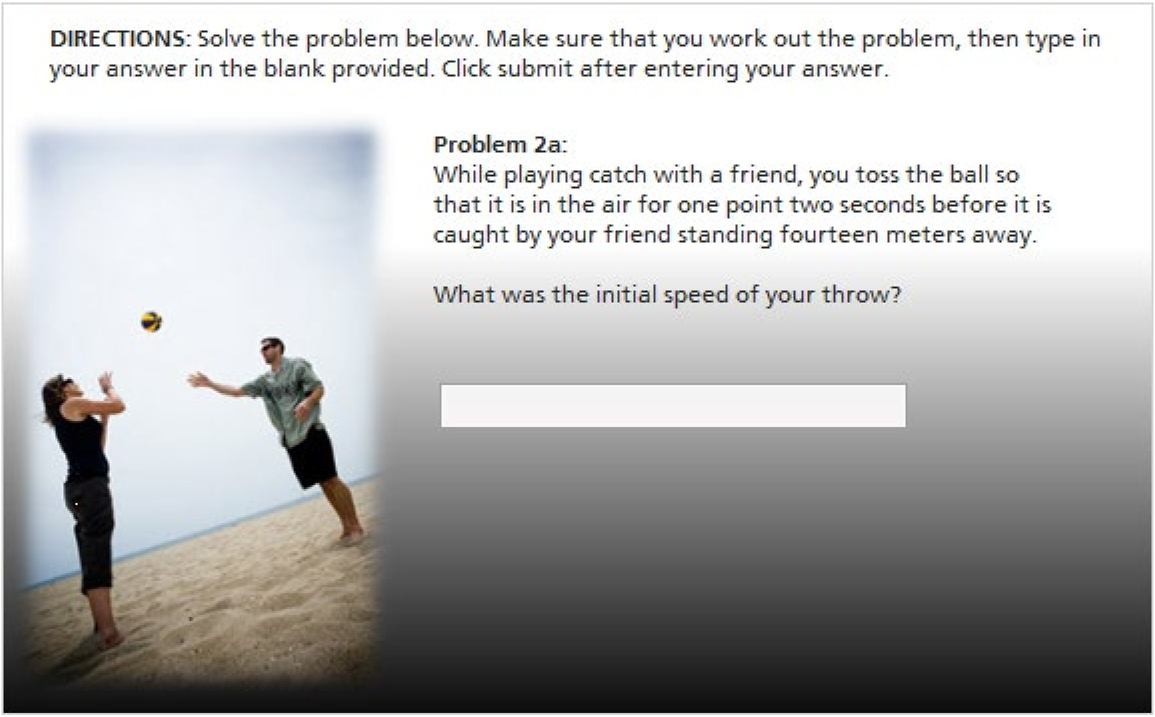


Since we know the initial vertical velocity, we can find the maximum height by recognizing that this is where the vertical velocity momentarily slows to zero.

Now we can use the equation v squared equals v zero squared plus two g y.

Substituting and solving, we see that the shell rises three thousand four hundred meters at its highest point.

Problem 2a



While playing catch with a friend, you toss the ball so that it is in the air for one point two seconds before it is caught by your friend standing fourteen meters away. What was the initial speed of your throw?

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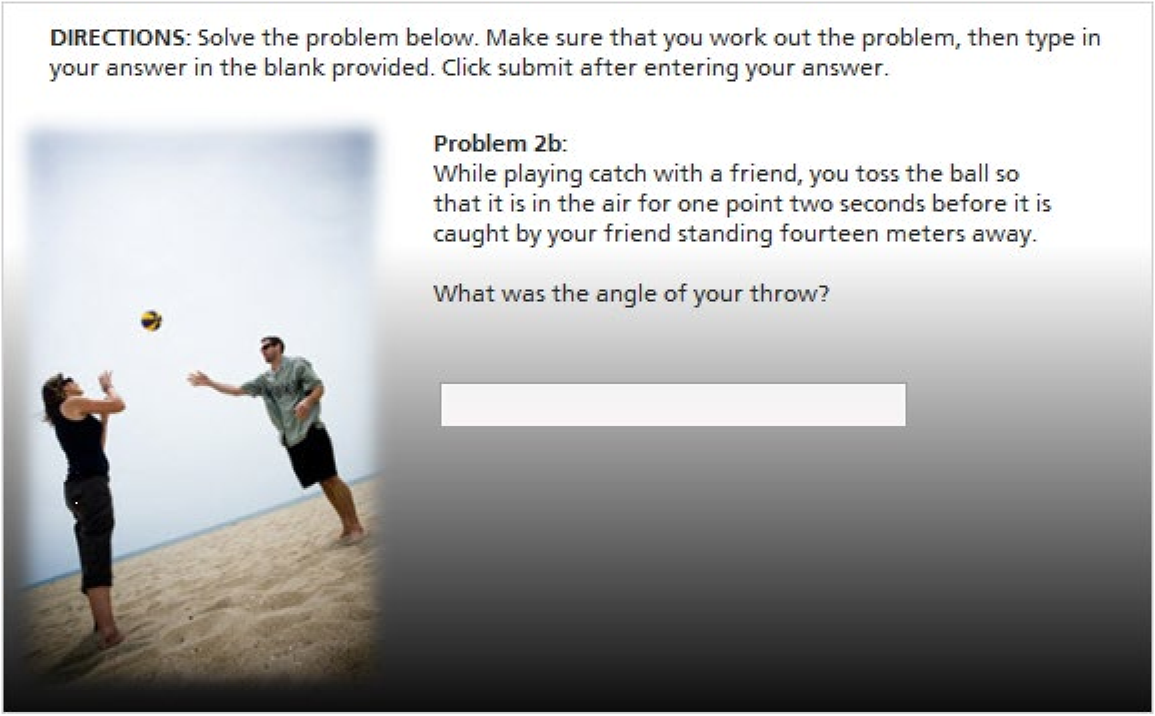
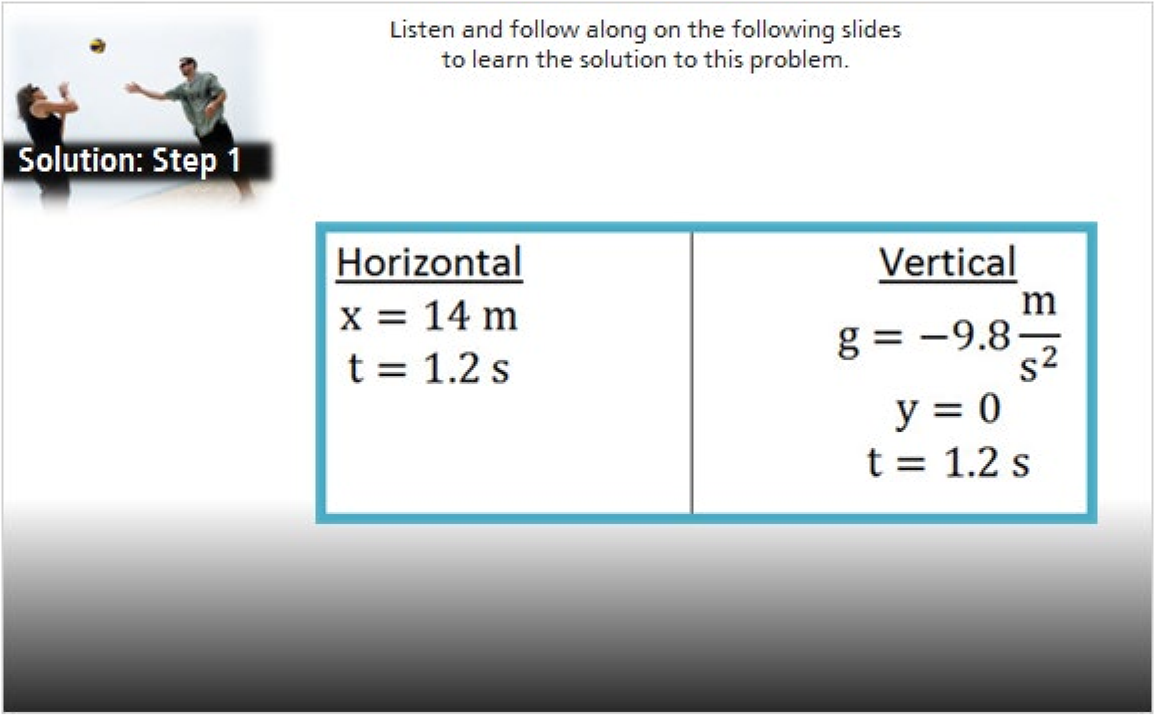
Problem 2b



While playing catch with a friend, you toss the ball so that it is in the air for one point two seconds before it is caught by your friend standing fourteen meters away. What was the initial angle of your throw?

Problem 2 Solution Step 1



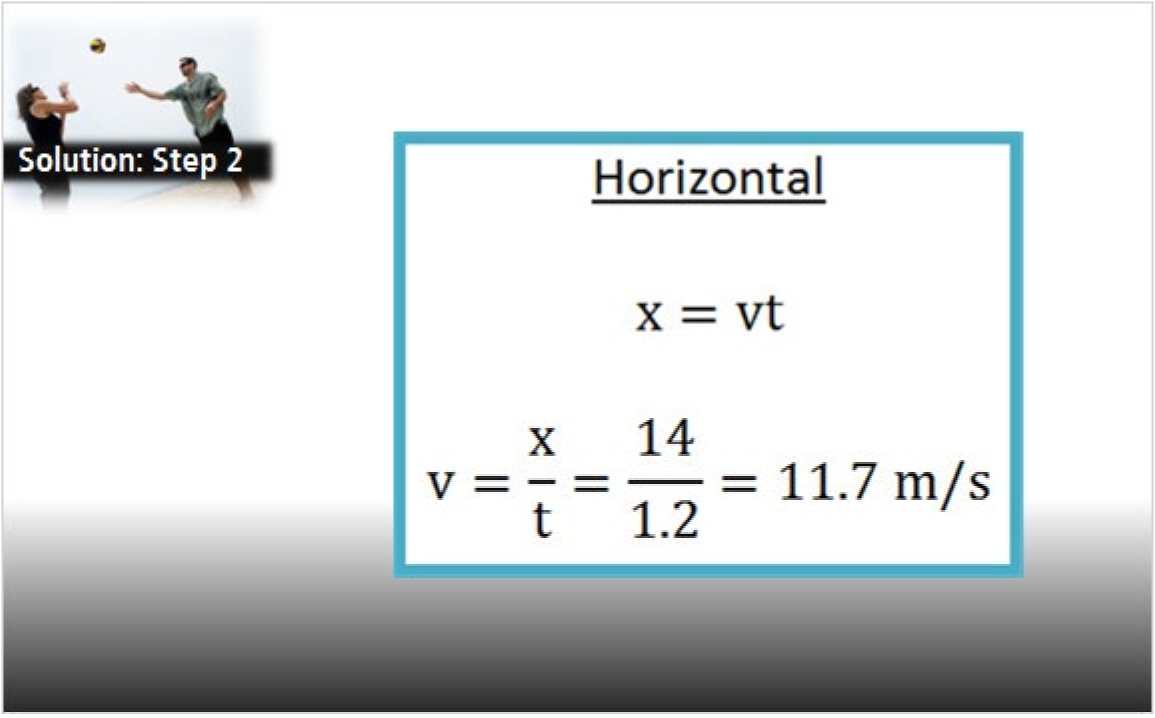
Your first step is to write down what you know in both the horizontal and vertical directions.

Horizontally, we know that the ball travels fourteen meters to get to your friend. We also know that the time in the air is one point two seconds.

Vertically, we know that the acceleration is nine point eight meters per second squared in a negative direction. We also know that the ball returns to its same height when caught, so the vertical displacement is zero. The time is the same in the vertical and horizontal direction and is given as one point two seconds.

To determine the initial velocity and angle of the throw, we will need to know both the initial horizontal and vertical components of the velocity, which we can then combine with trigonometry to determine the velocity and angle.

Problem 2 Solution Step 2



The horizontal velocity is fairly straightforward. We know that the displacement is the velocity times time, so the velocity is displacement divided by time. Substituting and solving, we see that the initial horizontal velocity is eleven point seven meters per second.

Problem 2 Solution Step 3

<u>Vertical</u>

$$y = v_0 t + \frac{1}{2} g t^2$$

$$0 = v_0(1.2) + \frac{1}{2}(-9.8)(1.2^2)$$

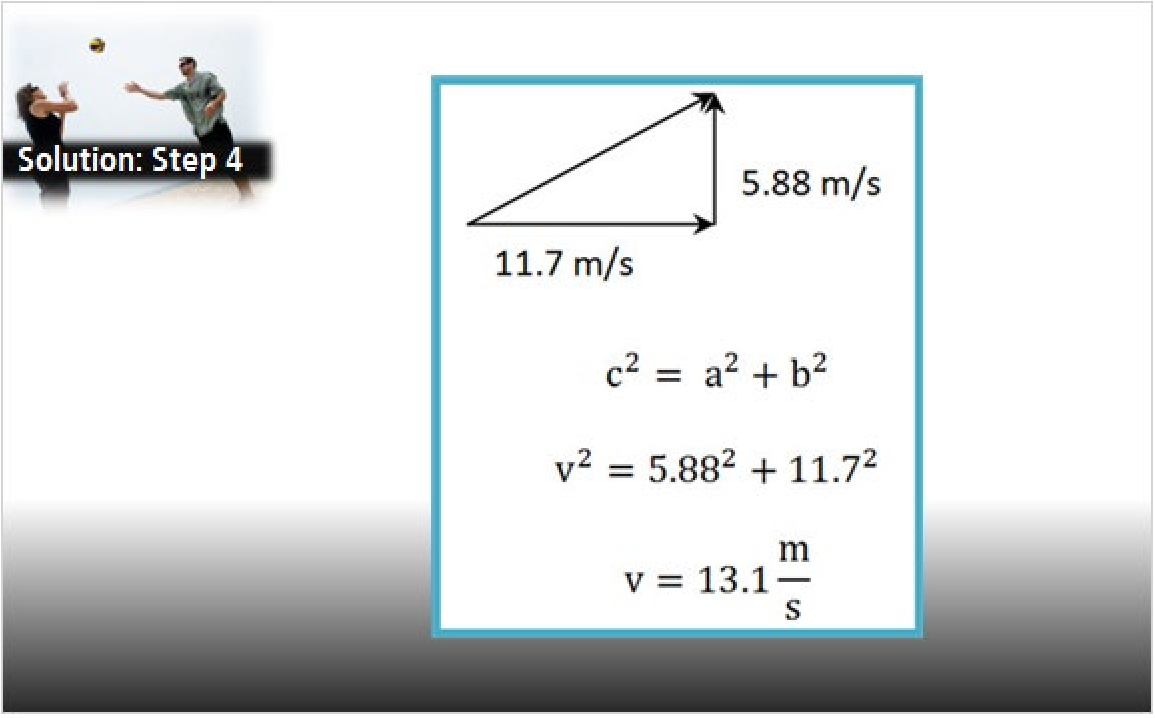
$$7.056 = 1.2 v_0$$

$$v_0 = 5.88 \frac{m}{s}$$

In the vertical direction, to solve for the initial velocity, we can use the equation y equals v zero t plus one half g t squared.

Substituting and solving, we see that the initial vertical velocity was five point eight eight meters per second.

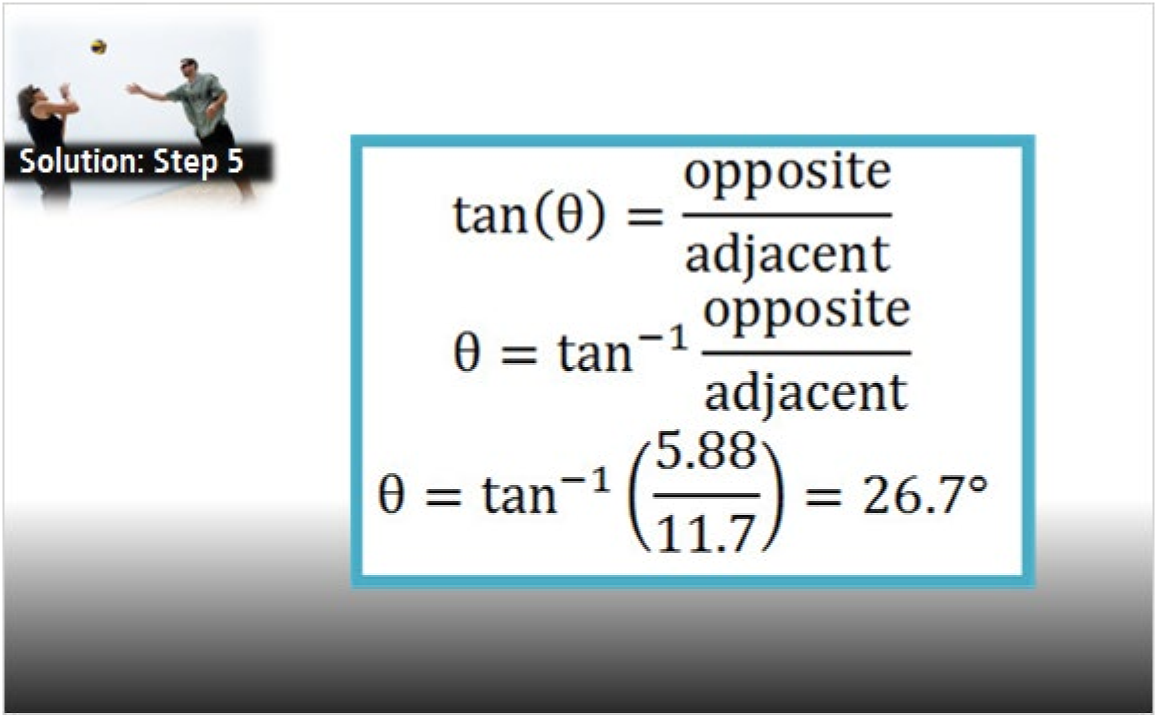
Problem 2 Solution Step 4



Now, we need to combine these initial horizontal and vertical components of the velocity. To do this, we will line them up head to tail to form a right triangle and use the Pythagorean Theorem to determine the hypotenuse, which is the magnitude of the initial velocity.

Substituting and solving, we see that the ball was thrown with a velocity of thirteen point one meters per second.

Problem 2 Solution Step 5



Now, to determine the angle, we need to use an inverse trig function. The tangent of the angle is the opposite over the adjacent, so the angle is equal to the inverse tangent of the opposite over the adjacent.

Substituting and solving we see that the ball was thrown with a speed of thirteen point one meters per second at an angle of twenty six point seven degrees above the horizontal.