Physics 122

Learning Opportunities

April 20 - 24

Projectiles Launched at an Angle

Most projectiles start at an angle with the horizontal and therefore have initial velocity in both the horizontal (x) and vertical (y) directions. Their trajectories are described as parabolas. The formula for the x-direction ($\Delta x = (v_{ix})(\Delta t)$) uses v_{ix} which is the constant velocity in the x-direction. The formula for the y-direction ($\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2$) includes the initial velocity v_{iy} but the velocity in the y-direction changes throughout the motion due to the influence of gravity. The motion in the x and y direction share the same Δt value and this serves as a link between the two equations. Because we are on Earth, $a_y = -9.81\ m/s^2$ due the effect of gravity on the object. The final velocity in the y direction is calculated as $v_{fy} = v_{iy} + a_y\Delta t$

See the documents section of my Teacher's Page or the Physics 122 page on Microsoft Teams for a sample problem and answers to the following practice problems.

Practice Problems

1. A baseball player hits a home-run to win the game. They struck the ball at a height of 1.4 m above the ground and the ball was launched at an initial angle of 42º with an initial velocity of 32 m/s. The ball was caught by a fan 4.2m above the ground.
   (a) How long was the ball in the air for?
   (b) How far horizontally did the ball travel?
   (c) What was the final velocity (including direction) of the ball as it enters the fan's hand?

2. A ball is bit at an angle of 35° above the horizontal with an initial velocity of 56 m/s. The outfield fence is 3.15 m high and 323m away. Will the ball go over the fence?

Projectiles with Symmetrical Trajectories

If an object lands at the exact same level it is launched ($\Delta y = 0$) ,the trajectory will be a perfectly symmetrical parabola. The formulas used for symmetrical trajectories are as follows:

$R = \dfrac{v_i^2 \sin 2\vartheta}{g}$ to calculate the range

$H = \dfrac{v_i^2 \sin^2 \vartheta}{2g}$ to calculate the height

$T = \dfrac{2v_i \sin \vartheta}{g}$ to calculate the time

Use $+9.81 m/s^2$ for g. The formulas have been designed to take into account the fact that gravity is in the negative direction.

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Practice Problems

1. A cannon ball is launched in a perfectly symmetrical trajectory. It was initially launched at an angle of 30.0º at an initial velocity of 24 m/s.
    a. What was the range of the cannon ball?
    b. What was the maximum height the ball reached?
    c. How long was the ball in the air?

2. A soccer ball is kicked into the air at an angle of 27.0º above the horizontal. The initial velocity of the ball is 18.0 m/s. The field is perfectly level.
    a. How long is the soccer ball in the air?
    b. What is the horizontal distance traveled by the soccer ball?
    c. What is the maximum height reached by the soccer ball?