Projectile Motion

Projectile Motion

- **Projectiles**
  - > **objects given an initial velocity that then move under the force of gravity**
- **Trajectory**
  - > **the path followed by a projectile**

Independence of Dimensions

Why do both balls hit at the same time?

Independence of Dimensions

- Since the horizontal and vertical motion of an object are independent of each other, the motion equations can be used to determine the exact position of a projectile.
- However, we must first distinguish between the x and y components of any vectors.

Independence of Dimensions

- With no acceleration in the horizontal direction, we can find the horizontal <u>position</u> by using the equation:
  - $x = v_{0(x)}t + ½\, a_x t^2$
- The <u>velocity</u> in the horizontal direction will not change, therefore:
  - $v_x = v_{0(x)} + a_x t$

Independence of Dimensions

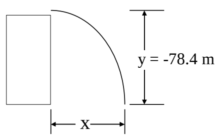
- Since there <u>is</u> acceleration (gravity) in the vertical direction the position can be found using the equation:
  - $y = v_{0(y)}t + ½\, a_y t^2$
- The acceleration causes a change in velocity in the vertical direction. We can find the final velocity using the equation:
  - $v_{(y)} = v_{0(y)} + a_y t$

Projectile Problem

- A stone is thrown horizontally at a speed of 5 m/s from the top of a cliff 78.4 m high.
  - > How long is the the stone in the air?
  - > How far from the cliff does the stone land?
  - > What is the horizontal and vertical components of the velocity just before the stone hits the ground?

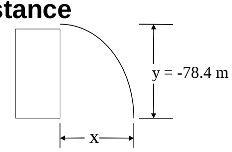
Projectile Problem

- Find the time
  - > $y = v_{0(y)}t + ½ a_y t^2$
  - > $y = ½ a_y t^2$
  - > $t^2 = 2y / a_y$
  - > $t^2 = 2(-78.4\ m) / (-9.8\ m/s^2) = 16\ s^2$
  - > $t = 4\ s$



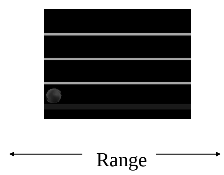
Projectile Problem

- Find the horizontal distance
  - > $x = v_x t$
  - > $x = (5.0\ m/s)(4.00\ s)$
  - > $x = 20\ m$
- Find the components
  - > $v_x = 5.0\ m/s$
  - > $v_{(y)} = a_y t = (-9.8\ m/s^2)(4.00s) = -39.2\ m/s$



Projectiles Launched at an Angle

- When projectiles are launched at an angle, they are given an initial horizontal and vertical velocity.
- The horizontal distance the projectile travels is called the <u>range</u>.

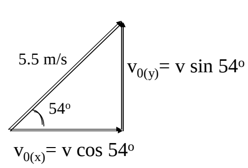


Angled Launch Problem

- A ball is thrown with a initial velocity of 5.5 m/s at an angle of 54º. Find:
  - > the time in the air.
  - > how high the ball went.
  - > what the range was.

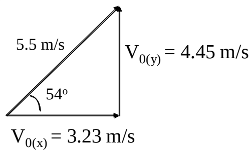
Angled Launch Problem

- Find components
  - $\Rightarrow v_{0(x)} = 5.5 \cos 54^o$
  - $\Rightarrow v_{0(x)} = 3.23$ m/s
  - $\Rightarrow v_{0(y)} = 5.5 \sin 54^o$
  - $\Rightarrow v_{0(y)} = 4.45$ m/s



Angled Launch Problem

- Find time at y = 0
  - > $0 = v_{0(y)}t + \frac{1}{2} a_y t^2$
  - > $t^2 = -2v_{0(y)} / a_y$

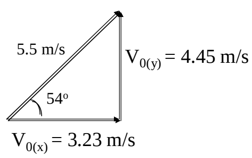


  - > $t^2 = -2(4.45 m/s) / (-9.8 m/s^2)$
  - > $t = .91s$

Or use the quadratic formula

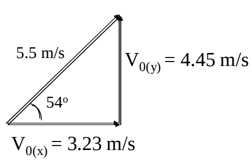
Angled Launch Problem

- Find Max height
- Maximum height occurs at t / 2.
  - > $y = v_{0(y)} t + \frac{1}{2} at^2$
  - > $y = (4.45)(.45) + \frac{1}{2} (-9.8)(.45)^2$
  - > $y = 1.01$ m



Angled Launch Problem

- Find range
  - > $x = v_x t$
  - > $x = (3.23 m/s)(.91s)$
  - > $x = 2.9m$



Projectiles Launched at an Angle

- **It can be proven using trigonometric identities that the range of the projectile can be found using:**
  - $R = \frac{v_0^2}{g} \sin 2\theta$

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