A Projectile Is Launched Straight Upwards At 75 M/s. Three Seconds Later, Its Velocity Is...?

A Projectile Is Launched Straight Upwards At 75 M/s. Three Seconds Later, Its Velocity Is...?

Understanding the motion of projectiles is a fundamental aspect of physics that blends concepts of kinematics and dynamics. When an object is launched vertically with an initial velocity, it is subject to gravitational acceleration, which influences its velocity and position over time. In this article, we will explore how to determine the velocity of a projectile launched straight upward at 75 meters per second after three seconds, delving into the principles of vertical motion, the equations involved, and practical applications.

Fundamentals of Vertical Projectile Motion

Before calculating the velocity after a specific time, it is essential to understand the basic principles governing vertical projectile motion.

Key Concepts and Definitions

- **Initial Velocity (u):** The velocity at which the projectile is launched. In this case, u = 75 m/s.
- **Acceleration Due to Gravity (g):** The constant acceleration acting downward, approximately 9.81 m/s^2 on Earth.
- **Time (t):** The elapsed time since launch. Here, t = 3 seconds.
- **Velocity at Time t (v):** The velocity of the projectile after time t, which we want to determine.

Basic Kinematic Equation for Velocity

The velocity of an object in uniformly accelerated motion is given by:
$$v = u + a \times t$$
where:
- v = velocity after time t,
- u = initial velocity,
- a = acceleration (for free fall, $a = -g$ since gravity acts downward),
- t = time elapsed.

Calculating Velocity After 3 Seconds

Applying the kinematic equation to our scenario:

Step 1: Identify Known Values

1. Initial velocity, $u = 75\, \text{m/s}$
2. Acceleration due to gravity, $g = 9.81\, \text{m/s}^2$
3. Time, $t = 3\, \text{seconds}$

Step 2: Apply the Equation

Since the projectile is moving upwards against gravity, the acceleration is negative:

$$v = u - g \times t$$

Step 3: Perform the Calculation

$$
v = 75\, \text{m/s} - (9.81\, \text{m/s}^2 \times 3\, \text{s}) \\
v = 75\, \text{m/s} - 29.43\, \text{m/s} \\
v \approx 45.57\, \text{m/s}
$$

Result: After three seconds, the velocity of the projectile is approximately 45.57 meters per second in the upward direction.

Understanding the Motion Dynamics

Knowing the velocity after a certain period provides insight into the projectile's position and the overall journey.

Velocity Reduction Over Time

- The initial velocity is 75 m/s.

- Due to gravity, the velocity decreases by approximately 9.81 m/s each second.
- After 3 seconds, the upward velocity is about 45.57 m/s, indicating the projectile is still ascending but with reduced speed.

Time to Reach Maximum Height

- The projectile reaches its maximum height when its velocity becomes zero.
- Using $v = u - g \times t$, set $v = 0$:

$$0 = 75\, \text{m/s} - 9.81\, \text{m/s}^2 \times t$$

$$t = \frac{75}{9.81} \approx 7.64\, \text{seconds}$$

- So, the projectile reaches its highest point approximately 7.64 seconds after launch.

Position at 3 Seconds

Using the displacement equation:

$$s = ut - \frac{1}{2} g t^2$$

$$
s = 75\, \text{m/s} \times 3\, \text{s} - \frac{1}{2} \times 9.81\, \text{m/s}^2 \times (3\, \text{s})^2 \\
s = 225\, \text{m} - 0.5 \times 9.81 \times 9 \\
s = 225\, \text{m} - 44.145\, \text{m} \\
s \approx 180.86\, \text{meters}
$$

The projectile is approximately 180.86 meters above the launch point after three seconds.

Practical Applications and Related Concepts

Understanding projectile motion isn't solely academic; it has many real-world applications across various fields.

Applications in Engineering and Sports

- **Ballistics:** Calculating projectile paths in firearms, artillery, and space missions.
- **Sports:** Analyzing the trajectory of balls in basketball, golf, or baseball.
- **Engineering:** Designing amusement park rides, such as drop towers or roller coasters, considering vertical motion.

Related Concepts and Calculations

- **Maximum Height:** The highest point in the projectile's trajectory, calculated as:
$$
H_{max} = \frac{u^2}{2g}
$$

- **Time of Flight:** Total time the projectile remains in the air, especially when launched and landing at the same height:
$$
T = \frac{2u}{g}
$$

- **Range:** Horizontal distance covered when launched at an angle, which combines horizontal and vertical components.

Summary and Key Takeaways

- The velocity of a projectile launched straight upward decreases linearly over time due to constant acceleration from gravity.
- After 3 seconds, the velocity can be calculated using the basic kinematic equation $v = u - g \times t$.
- For the given initial velocity of 75 m/s, the velocity after 3 seconds is approximately 45.57 m/s upward.
- The projectile continues to ascend until its velocity reaches zero at around 7.64 seconds, after which it begins descending.
- Calculating position, maximum height, and total time of flight involves similar kinematic equations and provides comprehensive insight into projectile behavior.

Conclusion

Mastering projectile motion calculations empowers students, engineers, and physicists to predict and analyze the behavior of objects in vertical motion accurately. Whether designing safety features in amusement parks, optimizing sports techniques, or planning aerospace missions, understanding how to determine velocity at any given time is vital. The simple yet powerful equations of kinematics serve as the foundation for these analyses, illustrating the elegant physics governing motion under gravity.

Meta Description: Discover how to calculate the velocity of a projectile launched straight upward at 75 m/s after three seconds. Learn key concepts, equations, and practical applications of vertical projectile motion.

Frequently Asked Questions

What is the velocity of a projectile launched straight upwards at 75 m/s after 3 seconds?

The velocity after 3 seconds is approximately 52 m/s upward.

How do you calculate the velocity of an upward-launched projectile after a certain time?

Use the equation $v = v_0 - g t$, where v_0 is initial velocity, g is acceleration due to gravity ($9.8 m/s^2$), and t is time elapsed.

What is the initial velocity of the projectile in this problem?

The initial velocity is 75 meters per second upward.

What is the acceleration acting on the projectile during its flight?

The acceleration is due to gravity, approximately $-9.8 m/s^2$ downward.

How long does it take for the projectile to reach its peak height?

It takes about 7.65 seconds to reach the peak height, calculated as v_0 / g.

What is the maximum height reached by the projectile?

The maximum height is approximately 283.7 meters, calculated using $h = v_0 t - 0.5 g t^2$ at the peak.

Is the velocity of the projectile zero at its peak height?

Yes, the velocity is zero at the maximum height before it starts descending.

What is the velocity of the projectile 3 seconds after launch?

The velocity is approximately 52 m/s upward, calculated as $v = 75 - 9.8 3$.

If the projectile was launched at 75 m/s, when will it hit the ground?

It will hit the ground approximately 15.3 seconds after launch, considering the total time to ascend and descend.

How does gravity affect the projectile's velocity over time?

Gravity decreases the upward velocity by 9.8 m/s every second, eventually bringing it to zero at the peak and reversing the direction during descent.

Additional Resources

A projectile is launched straight upwards at 75 m/s. Three seconds later, its velocity is...?
This question encapsulates fundamental principles of kinematics, specifically the motion of objects under constant acceleration due to gravity. Understanding how the velocity of a projectile changes over time is essential in physics, engineering, and many real-world applications such as ballistics, sports, and aerospace engineering. In this guide, we will explore the detailed mechanics behind the projectile's motion, walk through the calculations step-by-step, and highlight key concepts to help you understand how the velocity evolves after a given period.

Understanding the Problem

Before diving into calculations, it’s crucial to interpret the problem correctly:

- The projectile is launched straight upwards.
- Initial velocity, u = 75 m/s.
- The motion is influenced solely by gravity, assuming no air resistance.
- The question asks: What is the velocity of the projectile 3 seconds after launch?

Fundamental Concepts of Vertical Projectile Motion

1. Key Variables and Definitions
- Initial velocity (u): The velocity at which the projectile is launched.
- Final velocity (v): The velocity at a specific time after launch.
- Time (t): The duration from launch to the moment we observe.
- Acceleration due to gravity (g): The acceleration acting downward, approximately 9.81 m/s² near Earth's surface.
- Displacement (s): The height change from the launch point.

2. Assumptions for Simplification
- No air resistance or other forces besides gravity.
- The acceleration due to gravity remains constant at 9.81 m/s² downward.
- Upward motion is considered positive; downward acceleration is negative.

Step-by-Step Calculation of Velocity after 3 Seconds

1. Recognize the Kinematic Equation

The primary equation relating initial velocity, acceleration, and velocity after time t is:

$$ v = u + a t $$

Where:
- v is the final velocity.
- u is the initial velocity.
- a is the acceleration (negative in this case).
- t is the elapsed time.

2. Assign Known Values

- $u = 75\, \text{m/s}$
- $a = -9.81\, \text{m/s}^2$ (since gravity opposes the upward motion)
- $t = 3\, \text{seconds}$

3. Perform the Calculation

Plugging into the equation:

$$ v = 75\, \text{m/s} + (-9.81\, \text{m/s}^2) \times 3\, \text{s} $$

$$ v = 75\, \text{m/s} - 29.43\, \text{m/s} $$

$$ v = 45.57\, \text{m/s} $$

Therefore, the velocity of the projectile 3 seconds after launch is approximately 45.57 m/s upward.

Interpreting the Result

The positive value indicates that after 3 seconds, the projectile is still moving upward, albeit at a reduced speed compared to the initial launch velocity. This makes sense because gravity decelerates the projectile during its ascent.

Additional insights:
- Time to reach maximum height:
The velocity becomes zero at the peak of the trajectory.
Using $v = u + a t$, setting $v = 0$:

$$ 0 = 75 - 9.81 \times t_{up} $$

$$ t_{up} = \frac{75}{9.81} \approx 7.64\, \text{seconds} $$

So, it takes approximately 7.64 seconds to reach the maximum height, meaning after 3 seconds, the projectile is still ascending.

- Maximum height:
Can be calculated using:

$$ s_{max} = u t_{up} + \frac{1}{2} a t_{up}^2 $$

But that’s beyond the scope of this specific question, which focuses on velocity at 3 seconds.

Visualizing the Motion

Imagine the projectile's journey:

- Launch: At 0 seconds, velocity is 75 m/s upward.
- During ascent: Gravity slows it down, decreasing velocity over time.
- At 3 seconds: Velocity has decreased to approximately 45.57 m/s upward.
- Approaching the peak: The velocity continues decreasing until it reaches zero at about 7.64 seconds.
- Descent: After reaching maximum height, velocity reverses direction, becoming negative (downward).

Key Concepts and Formulas in Vertical Projectile Motion

1. Velocity at any time t:

$$ v = u + a t $$

2. Displacement after time t:

$$ s = ut + \frac{1}{2} a t^2 $$

3. Time to reach maximum height:

$$ t_{up} = \frac{u}{g} $$

4. Maximum height:

$$ s_{max} = u t_{up} + \frac{1}{2} a t_{up}^2 $$

Common Variations and Related Problems

1. When does the projectile hit the ground?

- Find when displacement $s = 0$ (assuming launch and landing at same height):

$$0 = ut + \frac{1}{2} a t^2 \Rightarrow t = 0 \text{ (initial launch)} \text{ or } t = \frac{-2u}{a}$$

Since $a = -9.81\, \text{m/s}^2$:

$$t = \frac{2u}{g} \approx \frac{2 \times 75}{9.81} \approx 15.3\, \text{seconds}$$

2. Speed at impact (when hitting the ground):

- Use $v = u + a t$, with $t \approx 15.3\, \text{s}$:

$$v = 75 - 9.81 \times 15.3 \approx 75 - 150.0 = -75\, \text{m/s}$$

The negative sign indicates downward motion.

Practical Applications and Considerations

Understanding projectile velocity after a certain time is vital in:

- Ballistics: Calculating the trajectory of projectiles.
- Sports: Determining how high and fast a ball travels.
- Engineering: Designing launch systems or safety measures.
- Aerospace: Planning spacecraft launches and re-entries.

Air Resistance and Real-World Factors

In real-world scenarios, air resistance would slow the projectile more than gravity alone. This would require more complex modeling involving drag coefficients and differential equations, but for basic physics problems, ignoring air resistance yields sufficiently accurate insights.

Summary and Final Thoughts

- When a projectile is launched vertically at 75 m/s, its velocity after 3 seconds can be calculated straightforwardly using the equation $v = u + a t$.
- The velocity after 3 seconds is approximately 45.57 m/s upward.
- The projectile continues to ascend until its velocity reaches zero at around 7.64 seconds.
- These calculations demonstrate the predictable nature of motion under constant acceleration, governed by well-established kinematic equations.

By mastering these principles, you can analyze a wide range of motion problems involving projectiles, acceleration, and time, building a solid foundation in classical mechanics.

Understanding how the velocity of a projectile changes over time is key to predicting its path and behavior. Whether for academic pursuits, engineering design, or practical applications, these principles serve as fundamental tools in the physicist's toolkit.

A Projectile Is Launched Straight Upwards At 75 M S Three Seconds Later Its Velocity Is

A Projectile Is Launched Straight Upwards At 75 M S Three Seconds Later Its Velocity Is

Related Articles

- The Mid Point Of The Sides Of A Triangle Are (1,5,-1),(0,4,-2),(2,3,4) Find The Vertices
- Which Equation Represents The Graphed Function?y=-3x + 3y = 3x - 3y = 3x - 1/3y = -1/2x + 3
- Doreen Spends Most Of Her Day Researching Human Disease And Health. She Is Most Likely A

Back to Home