Kinematic Equations and Free Fall

Kinematic Equations and Free Fall

- **An object in free fall experiences an acceleration of -9.8 m/s².**
- **If an object is merely dropped from an elevated height to the ground below, then the initial velocity of the object is 0 m/s.**
- **If an object is projected upwards in a perfectly vertical direction, then it will slow down as it rises upward. The instant at which it reaches the peak of its trajectory, its velocity is 0 m/s.**

Kinematic Equations and Free Fall

- **If an object is projected upwards in a perfectly vertical direction, then the velocity at which it is projected is equal in magnitude and opposite in sign to the velocity which it has when it returns to the same height.**
- **That is, a ball projected vertically with an upward velocity of +30 m/s will have a downward velocity of -30 m/s when it returns to the same height.**

Example 1

- **Luke Autbeloe throws his mother's favorite crystal vase vertically upwards. If it rises to a height of 35 meters, determine how long the vase will be in the air (which is exactly how long Luke has to live if he doesn't catch the vase).**

Diagram the problem

Determine known and unknown

V_i = 0 m/s $\quad a$ = -9.8 m/s²

ΔY = -35 m $\quad t$ = ??? s

Solve for the time it takes to fall and then multiply by 2 to get the total time.

Choose the correct kinematic equation:

$$\Delta Y = V_i t + \tfrac{1}{2} a t^2$$

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Insert the correct values and solve.

$$-35m = (0m/s)t + \tfrac{1}{2}(-9.8m/s^2)t^2$$

$$-35m = (-4.9m/s^2)t^2$$

$$(-35m)/(-4.9m/s^2) = t^2$$

$$7.14s^2 = t^2$$

$$2.67s = t$$

$$(2.67s)2 = total\ \text{t}$$

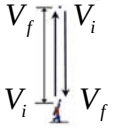
t = 5.34 s

Example 2

- **The daisy BB gun (being fired by a gazelle) can fire a BB at 219.5 m/s. How high will the BB go if it is fired straight up into the air? How long will the BB remain airborne?**
- **HINT: In my opinion it is best to work the back half of the problem. . .in this case you will solve for how far the BB dropped. . .but it fell as far as it went up which is why the actual answer should be positive!!!**

How High?

Diagram the problem



Determine known and unknown

V_i = 0 m/s $\quad a$ = -9.8 m/s^2

ΔY = ???? $\quad t$ = ??? s

V_f = - 720 ft/s = - **219.5** m/s

Solve for the distance it takes to fall and then that tells you how high it went.

Chose the correct kinematic equation:

$$V_f^2 = V_i^2 + 2a\Delta Y$$

How High?

$$V_f^2 = V_i^2 + 2a\Delta Y$$

Insert the correct values and solve.

$$(-219.5m/s)^2 = (0m/s)^2 + 2(-9.8m/s)\Delta Y$$

$$\Delta Y = -2458.2m$$

How High = +2458.2m.

How Long?

Determine known and unknown

V_i = 219.5 m/s $\quad a$ = -9.8 m/s^2

V_f = - 219.5 m/s $\quad t$ = ??? s

$$V_f = V_i + at$$

$$-219.5m/s = 219.5m/s + (-9.8m/s)t$$

t = 44.8 s

Practice

- A cliff diving gazelle jumps straight upward with a velocity of 5 m/s. If the gazelle hits the water 2.8 seconds later, how high was the cliff?

Known:

V_i = 5 m/s

a = -9.8 m/s^2

t = 2.8 s

Unknown:

Δy = ??

$$\Delta y = V_i t + \frac{1}{2}at^2$$

$$\Delta y = (5m/s)2.8s + \frac{1}{2}(-9.8m/s^2)(2.8s)^2$$

$$\Delta y = -24.42\,m$$

The cliff was 24.42 m high