

Projectile Motion

12PHYS - Mechanics

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Do Now: Vector Recap

1. Yssy travels 30km south and then 20km west. Draw a vector diagram to show her total displacement.
2. Max and Lena are pushing a box. Max is pushing it with force 500N to the right, and Lena is pushing it with force 400N up. Draw a vector diagram to show the net force.
3. Phoebe is flying at $7ms^{-1}$ east. Phoebe changes direction so she flying at $7ms^{-1}$ south. Draw a vectoer diagram to show the change in velocity of Phoebe.

Projectile Motion

Projectile motion can be thought of as *motion under gravity*.



Step 1: Describing Velocity

To get into projectile motion we first need to correctly describe the velocity and acceleration of an object in motion.

A ball is thrown vertically upwards. **Describe the direction of the ball's velocity when:**

1. It is going up,
2. it is going down,
3. it is at the highest point.

Describe the direction of the ball's acceleration when it is:

1. Going up,
 2. going down,
 3. at the highest point.
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Forces on The Ball

We assume that friction force is negligible (we ignore it).

Therefore, *the only force* acting upon the ball while in the air is the ***weight force***.

$$F_{net} = F_{weight} \quad (1)$$

The ball experiences a constant downwards acceleration ($-9.8ms^{-2}$) at all times.

Acceleration Due to Gravity

$$g = 9.8ms^{-2} \quad (2)$$

The acceleration of any object in the air without its own power source.

So, Projectile Motion

- An object what moves through the air **without its own power source**,
 - only force acting upon it is the **weight force**,
 - always experiencing **downward acceleration of $9.8ms^{-2}$** .
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Question

A ball is thrown upwards with an initial speed of **161.3km/hr** ($44.8ms^{-1}$).

1. How long does it take for the ball to reach its highest point?
2. How high does the ball rise?

Remember: Knowns, Unknowns, Formula, Substitute, Solve

Question

Lachie kicks a rugby ball straight upwards. It is in the air for **10.6s** before it hits the ground.

1. What is the initial velocity of the ball?
2. How high does the ball rise?

Remember: Knowns, Unknowns, Formula, Substitute, Solve

Question

Angus is going cliff diving. He jumps and falls for **3.4s** before hitting the water below.

1. What is his **initial velocity**?
2. What is his **acceleration**?
3. What is his **final velocity** (as he hits the water)?
4. How **high** is the cliff?

Remember: Knowns, Unknowns, Formula, Substitute, Solve

A Classic: The Cannon Ball Question

A cannon ball is fired horizontally from the top of a hill. The velocity of the cannon ball is split into two components:

1. **Vertical motion**, and
2. **horizontal motion**.

Note: These motions are **independent of each other**. That is, they do not affect each other.

Vertical Motion

Recall: once in motion, the only force acting upon the cannon ball is the **weight force**. We are assuming friction is negligible.

Therefore:

The cannon ball is experiencing a constant downward acceleration of $g = -9.8ms^{-2}$.

Horizontal Motion

Recall: once in motion, the only force acting upon the cannon ball is the **weight force**. We are assuming friction is negligible.

Therefore, the cannon ball does not experience any forces in the horizontal direction. Therefore it does not accelerate in the horizontal direction.

Summary

$$ProjectileMotion = VerticalMotion + HorizontalMotion \quad (3)$$

Vertical Motion

Constant downwards acceleration of $-9.8ms^{-2}$.

Horizontal Motion

No acceleration, therefore constant speed. $v_i = v_f$

Thought Experiment

If the cannon ball is fired with a **greater horizontal velocity** will it take longer to hit the ground?

Question

A marble rolls off a desk of height 1.25m and with $v_x = 1.6ms^{-1}$.

1. Calculate the **duration of the fall**
2. During the fall, how far does the marble travel **horizontally**?
3. How far does the marble travel if $v_x = 3ms^{-1}$?