

# 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.

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### Projectile Motion

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



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## 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.

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## Acceleration Due to Gravity

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

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

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## 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

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## 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

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## 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

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## 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.

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## 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  $g = -9.8ms^{-2}$ .

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## 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.

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## Summary

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

## Vertical Motion

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

## Horizontal Motion

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

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## Thought Experiment

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

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## 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  $v_x = 3ms^{-1}$ ?