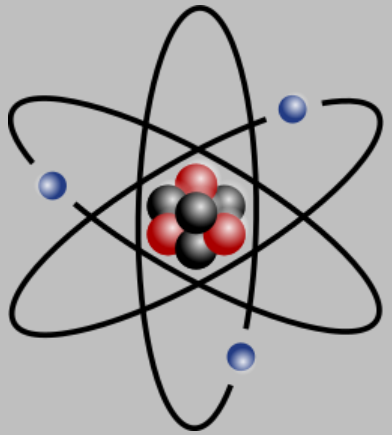
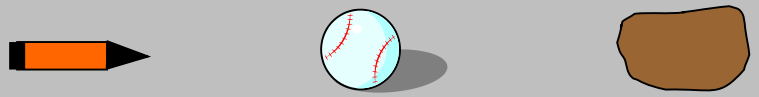
International House Tashkent
Subject: Physics
Department: ES, Course 1
Lesson 3. Projectiles launched horizontally



A bullet is shot, a baseball is thrown, and a rock is dropped – which object will hit the ground first if released from the top of the IDS Building?

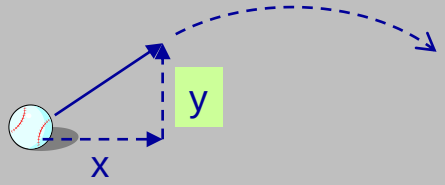


In order to answer this question, we must understand projectile motion.

What is a projectile?

- Any body that is thrown or projected into the air.
- Projectiles follow a curved path near the earth's surface because of gravity's effect on them.

- With <u>any</u> curved path, we can break the motion down into a vertical component and a horizontal component.



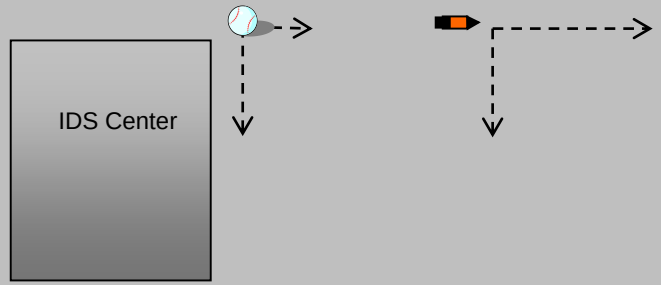
Let's start with the dropped rock.

- The falling rock is only under the influence of gravity. Therefore, if we know the height of the IDS building, we can calculate the time in which it takes to fall.

Remember: $d = 1/2gt^2$ or $t = \sqrt{\frac{2d}{g}}$

The baseball and the bullet can be treated similarly to one another.

- In the case of a projectile shot horizontally, it will have a horizontal velocity vector and a vertical velocity vector.



However, the only force that pulls the ball or bullet to the ground is gravity!

Therefore, the bullet and the ball will accelerate toward the ground at the same rate as the dropped rock.

So, which object will hit the ground first?

The rock, the baseball, and the bullet will all land at the same time! (Assuming there is no air resistance)

Will the rock, the bullet and the baseball all land in the same place?

NO!
Therefore, we need to look at that component separately.

How to determine the landing point of a projectile:

- Where a projectile lands is determined by the horizontal speed or velocity at which the object is released.
- Ignore the vertical pull of gravity at this time.

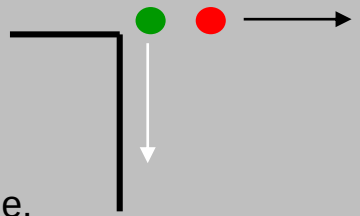
For example:
If a ball is thrown horizontally at a velocity of 20 m/s,
then after 1 second, it will traveled 20 meters, after 2 seconds,
40 meters, after 3 seconds, it has traveled 60 meters, etc…

The distance that the ball travels horizontally depends on the time it is in the air.

Let's look at a similar question:

A green ball is dropped from a cliff 20 meters above the ground. At the same time of release a second ball, red in color, is thrown horizontally off the cliff at a speed of 35 m/s.

Which ball will land first?



Both balls will land at the same time.
The both are under the same influence of gravity.

Where will each ball land in respect to the cliff?

That answer depends on the amount of time the balls are in the air.

To decide **where** the balls land, we need to determine how long the balls are in the air.

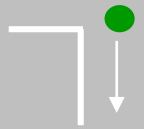
To do this, we need to use the equation that helps us determine the amount of time that the balls are actually falling. **$d = 1/2gt^2$**

So, $20\ m = ½\ (9.8\ m/s^2)\ t^2$

Solving for t, we get $t = \sqrt{\frac{20\ m}{(1/2)(9.8) m/s^2}}$ or $t = 2\ s$

<u>Both balls</u> will take 2 seconds to hit the ground.

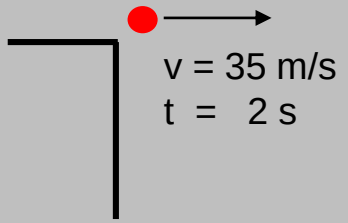
- The green ball will land directly under the point at which it was dropped. It goes straight down.



- But the red ball will land away from the cliff. The distance that the red ball lands away from the cliff is determined by looking at only the horizontal component.

The red ball is traveling at 35 m/s at the release.

It travels in the air for 2 seconds.



Using the equation, d = vt for linear motion,

The distance traveled in air is 35 m/s x 2 seconds = 70 meters.

The red ball will land 70 meters from the base of the cliff.