# Projectile Motion with Water Droplets

## Introduction

Help your students understand the independence of horizontal and vertical projectile motion! This stunning demo will mesmerize your students and solidify a crucial kinematics concept that is often difficult to visualize.

## Concepts

- Projectile Motion
- Newton's Laws
- Horizontal vs. vertical motion
- Free body diagrams

## Materials

Bucket
Clamp holders, 3
Extension buret clamp, 3
Function generator
Glass pipet, thin
Hoffman clamp
Latex Tubing
Rubber band
Stroboscope
Support stands, 3
Vibration Generator or Electromechanical Driver
Water faucet with serrated hose connection
Wooden block, small

## Safety Precautions

*Please keep the stroboscope facing away from your students due to risk of triggering epileptic episodes, particularly in the range of 7–15Hz. Keep hands and the lab area around electrical apparatus dry. Electrical Equipment near a water source must be grounded and plugged into a GFI outlet. Wipe up spills immediately. Follow all laboratory safety guidelines.*

## Preparation

1. Secure wooden block and tubing using rubber band as shown in Figure 1. The wooden block is held in place with a extension buret clamp.
2. Attach tubing to sink faucet.
3. Insert thin glass pipet on opposite end of rubber tubing.
4. Set up two support stands in a row with one clamp holder each making sure that the clamps are at equal heights. The support stands are for holding the pipet and the vibration generator at desired heights. Use as many stands as necessary to keep tubing as parallel to ground as possible.
5. Secure vibration generator to the support stand that precedes the stand holding the tubing end with the glass pipet.
6. Secure the end of the tubing with the glass pipet horizontally with an extension buret clamp.

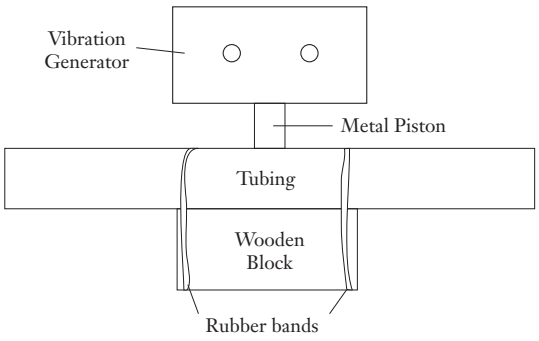


**Figure 1.**

7. Adjust vibration generator so that the movable metal piston is lightly pressing on the tubing that is secured to the wooden block (see Figure 1).
8. Attach Hoffman clamp to the tubing before the vibration generator.
9. Position the bucket so that it will collect the water streaming from the pipet



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## Procedure

1. Turn on the tap and adjust pressure so that water falls into bucket as a single narrow stream.
2. Connect function generator to vibration generator.
3. Turn on the function generator and set it to 100Hz.
4. Dim the lights.
5. Turn on the stroboscope and match the frequency of the stroboscope to that of the function generator so that the water droplets appear to be suspended in midair.

## Tips

- Depending on position of sink and length of tubes, different numbers of support stands may be used.
- You may need to adjust the amount of pressure exerted on the tube by the vibration generator and Hoffman clamp to get a proper water flow.
- It is very important that the glass pipet be as parallel to the floor as possible.
- Connection diagram is provided to help visualize the set up. See Figure 2

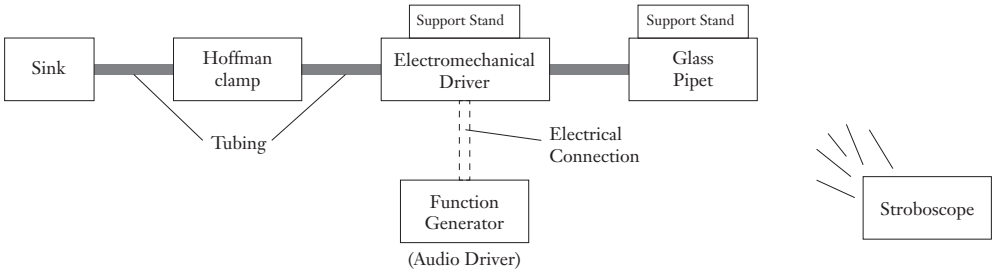


**Figure 2.**

- You may change the size of the pipet and the water pressure to observe what happens with different sized drops or different horizontal speed.
- Challenge your students to explain what happens when you change the frequency of the water droplets.
- A video for this demonstration is available for viewing as part of the Flinn Scientific Teacher Resource Minute Videos. Please visit the Flinn website at http://www.flinnsci.com for viewing information.

## Discussion

Projectile motion is when an object is thrown near the Earth's surface and follows a curved path under only the force of gravity. Learning about projectiles is a natural way of learning about horizontal and vertical components of vectors. The horizontal and vertical components of the motion vector are independent of each other in projectile motion. Since the only force acting on a projectile is gravity, the object only experiences a single downward force.

Newton's Second law tells us that this downward force results in a downward acceleration. This means that the projectile is speeding up in the downward vertical direction, that is, it is falling faster. In the horizontal direction there is no force acting on the projectile; therefore, its horizontal velocity remains constant throughout the entire path of the projectile (when neglecting air resistance). The water droplet demonstration stunningly shows this independent relationship of horizontal and vertical components of projectile motion. Each water droplet is exactly the same horizontal distance from adjacent droplets; however, the vertical distances between droplets increase as you follow the stream down. The stroboscope is flashing at 100Hz, which means that the positions of the drops are separated by 1/100th of a second. With this information it is possible to measure the distances between drops and use the data to calculate a value for the acceleration due to gravity.

$$g = \sqrt{2d}/t$$

## References

National STEM Centre Pearls of Water. http://www.nationalstemcentre.org.uk/elibrary/resource/10303/pearls-of-water (accessed November, 2015).

## Materials for *Projectile Motion with Water Droplets* are available from Flinn Scientific, Inc.

| Catalog No. | Description |
|---|---|
| AP5789 | Electromechanical Driver (Vibration Generator) |
| AP6529 | Audio Driver (Function Generator) |
| AP6394 | Stroboscope, Hand-held |
| AP8219 | Clamp Holder |
| AP8214 | Hoffman Type Clamp |
| AP8947 | Extension Buret Clamp |
| AP6009 | Bucket, Utility Pail |
| AP2078 | Tubing, Latex, Amber |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.