



databot™ Ninja Physics

 ACCELEROMETER

Overview

Get ready to take on **acceleration** and the **force** of **gravity**! In this exploration, you'll be challenged to demonstrate your Ninja-like abilities in a series of hands-on activities. Ninjas are known for being stealthy and doing the seemingly impossible. Is it possible to move with zero **acceleration** while remaining perfectly level? Let's explore further using your smart device as an **accelerometer** and find out!

Background

Gravity is an amazing, invisible **force** that affects all objects with mass - this **force** is what attracts every object to every other object. Since the **force** of **gravity** is generated by the **mass** of an object, this means that more **massive** objects will have a more powerful **force** of **gravity** than less **massive** objects. For example, a grain of salt and a planet both exert a gravitational **force**, however the planet, with more mass, exerts a higher **force**.

The pull of **gravity** accelerates objects towards one another based on their **mass**. Since Earth is big and has a lot of **mass**, it exerts a powerful accelerating **force** on us measured in meters per second squared (m/s^2). Using the **accelerometer** on your device you can see the **acceleration due to gravity** ($9.8 m/s^2$) - this is constant anywhere on Earth. If you drop from an airplane to skydive, you will accelerate at this rate until wind resistance prevents you from falling any faster. On the moon, this number would be different because the moon is less **massive**.

Acceleration is a change in **velocity** (speed in a specific direction). If an object is either at rest or traveling at a constant speed in the same direction, there is no **acceleration**. Any time there is a change in speed or direction, **acceleration** is happening. You can feel the **force** of **acceleration** when you are in a car that is going around a sharp corner, or if it suddenly speeds up and pushes you back into your seat! This is an invisible **force** you feel - but it can be seen using the sensors inside your smart device!

Balanced forces are when all forces acting upon an object are equal and there is no change in speed or direction - **acceleration** is at zero. When you hold up a weight, countering the **force** of **gravity** with your own strength, you are demonstrating "balanced forces."

May the force be with you!

Grades: 4th & Up

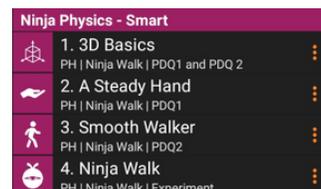
Time: 60 Minutes (PDQ's + Experiment)
+ optional extensions

Subject: Physics

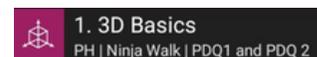
Topics: **Acceleration, Gravity, Acceleration due to Gravity, Balanced** and Unbalanced **Forces, Cartesian Coordinates**

What You Will Need/Prep

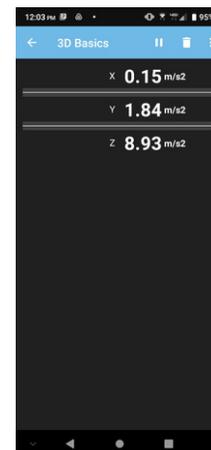
- Smart device - IOS or Android, phone or tablet!
- Install Vizeey™ on your Smart device. 
- Scan the QR code to load the exploration collection.



- Click on **3D Basics** in Vizeey™ to load the experiment.



- Press  to start and pause data collection.



- Study the background information and terms and prepare to explore!

Throughout this exploration you will watch changing values on the **Cartesian** axes Y and Z – these coordinates are used to provide position in three dimensions, like a mathematical way of looking at an object in 3D!

This makes sense since you will want to know exactly which direction(s) you are moving your smart device.

Specifically, you will monitor your rate of **acceleration** in one direction (Y) and if you are keeping your smart device level based on **acceleration due to gravity** (Z). Remember, **acceleration** is a “change” in **velocity**, and your challenge is to move with zero **acceleration**.



Can it be done?!

Learning Objectives

In this exploration you master the Ninja skills that are essential for stealth, balance, and precision.

- Visualize, collect and analyze data
- Use **Cartesian Coordinates** - x, y, and z axes
- Measure and record **acceleration**
- Measure & record **acceleration due to gravity**
- Visualize **balanced forces** in action

Important Terms

Acceleration: The rate of change in velocity. If an object is moving at a constant speed and direction, then its **acceleration** rate is zero!

Acceleration (due to gravity): On Earth, objects accelerate towards the center of the planet because they are attracted to it - this rate is constant at 9.8 m/s^2

Accelerometer: A sensor that detects **acceleration** - changes in speed and direction.

Balanced Forces: When all **forces** acting upon an object are equal and there is no change in speed or direction.

Cartesian Coordinates/Geometry: Describes direction and location in three dimensions (3D) using the **Cartesian coordinates** X, Y, and Z.

Force: Something that can change the motion of an object (such as **gravity** and **acceleration**).

Gravity: An attractive **force** between objects with **mass**. We call this **force** "attractive" because it always pulls **masses** together.

Mass: A physical property of an object; the amount of matter contained by a given volume of solids, liquids, or gases.

Variation: A change or difference in condition, amount, or level, typically with certain limits.

Velocity: The speed of an object moving in a specific direction.

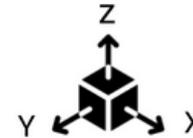
OpenStax High School Physics Connections

OpenStax is a hub for peer-reviewed, openly-licensed textbooks (available in free digital formats and affordable printing options). For further study and a deeper understanding of the concepts in this Exploration we recommend the OpenStax High School Physics Curriculum as a great free resource. An understanding of speed and velocity is key to understanding acceleration, and is addressed in Chapter 2, Motion in One Dimension. Chapter 3 provides a full treatment of Acceleration, and Chapter 4, Forces and Newton’s Laws, addresses these concepts in more detail.

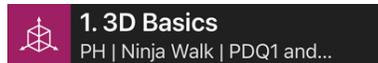
<https://openstax.org/details/books/physics>

PDQ 1: A Steady Hand

Using the **accelerometer** on your device it is possible to read the force of **gravity**! First, familiarize yourself with the orientation of your device using the 3D **Cartesian Coordinate** system of X, Y, and Z axes. The **accelerometer** reads forces across these 3 axes.



1. Click on **3D Basics** in Vizeey™ to load the first part of PDQ 1.
2. To start and to pause PDQ 1 and practice changing axes use:
3. Hold your device in the palm of your hand in this position. You should see 9.8 m/s² on the Z axis.
4. Next, rotate your device so you can see 9.8 m/s² on the X and Y axes.
5. Now that you have a good grasp of your axes use to return to the **Ninja Physics** explorations menu.



In this PDQ you can see **acceleration due to gravity** being displayed live. Rotate your device so that the Z axis is oriented "up" and you should see around 9.8 m/s² displayed on the third line.

Can you get a perfect 9.8 to display?

Rotate your device so that the X axis is now "up" and is reading a positive value for X around 9.8. Can you get it to show you a negative 9.8?

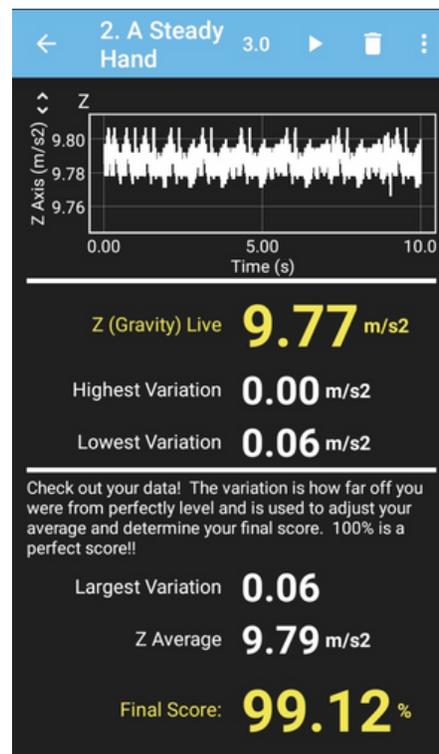
Why?

Now it's time to experiment.

1. Click on **A Steady Hand** in Vizeey™ to load the second part of PDQ 1.
2. **A Steady Hand** is a 10 second timed PDQ. This timed run gives you a 3 second delay to prepare then starts the timer!
3. Practice a few times before your official run.
4. Use to start and to pause the experiment.
5. Balance your device™ as close to 9.8 m/s² as possible for your 10 second run. GO!

How much you "vary" from the perfect 9.8 goal is your "variation" from level. As you move, the **force of gravity** shifts to other axes.

How close were you able to get to 100%? Record your score and share or compete with friends for the least variation and best average!



Time to joust with gravity - prepare to see **balanced forces** in action, you against **gravity**!

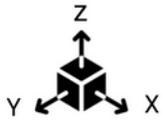
The yellow number is your "live" **acceleration** value, the white numbers display your biggest "swing" values from a perfect zero.

Your final score takes your average **acceleration** and adjusts it based on your highest variation. One high spike can take you down!

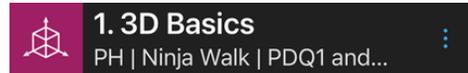
This graph visualizes your **acceleration** on the Y axis. A perfect walk with no **acceleration** will be completely flat. Big spikes represent **acceleration** and impact your score - be careful!

PDQ 2: Smooth Walker

Using the **accelerometer** on your smart device, practice your Ninja moves with zero **acceleration** (a steady pace) on the Y axis. First step? Let's identify the Y axis!



1. Click on **3D Basics** in Vizeey to load the first part PDQ 2.



2. Use to start and to this pause this part of PDQ 2.

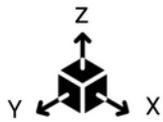
3. Hold your device in the palm of your hand, keeping it level, and move it about until you confirm the direction of the Y-axis. You want the Y-axis pointing straight ahead of you so can move steadily along this axis as you walk. Remember, **acceleration** is a "change" in your rate of speed or direction, so move steadily and strive for zero change and zero **acceleration**.

4. Now that you have a good understanding of your Y-axis, use to return the **Ninja Physics** explorations menu.



Sample 3D Basics

Now it's time to experiment.



1. Click on **Smooth Walker** in Vizeey to load the second part of PDQ 2.

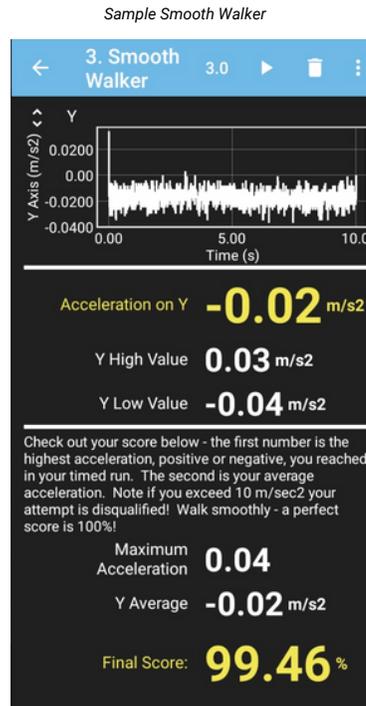


2. **Smooth Walker** is a 10 second timed PDQ. This timed run gives you a 3 second delay to prepare then starts the timer!

3. Practice a few times before your official run.

4. Use to start and to pause this part of PDQ2

How close were you able to get to 100%? Record your score and share or compete with friends for the best Final Score!



- The yellow number is your "live" **acceleration** value, the white numbers display your biggest "swing" values (variations) from a perfect zero.

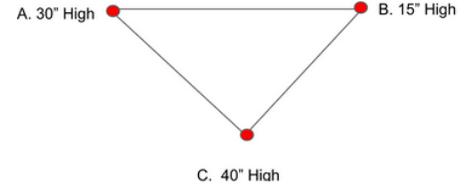
- Your final score takes your average **acceleration** and adjusts it based on your highest variation. One high spike can take you down!

This graph visualizes your **acceleration** on the Y axis. A perfect walk with no **acceleration** will be completely flat. Big spikes represent **acceleration** and impact your score - be careful!

Experiment: Ninja Walk

Welcome to the Ninja Walk - all your study and preparation is about to be put to use! The Ninja Walk combines your previous training as you strive to maintain a perfectly level device (as monitored by the **gravity** reading on the Z-axis) and as close to zero **acceleration** as possible on the Y-axis as you move through a three-point course. Good luck Ninjas!

- Set up your Ninja Walk as an equilateral triangle with 6' sides where each vertex is a designated "Ninja Zone" that Ninjas must navigate your device through.
- The different zones are at different heights to make it more challenging. Pick a point in the room to be "Zone A" and use a chair or desk that is approximately 30" off the ground to mark as A with a piece of tape. Now, use a protractor to measure a 60 degree angle and measure six feet to "Zone B" which will be 15" off the ground (use books, boxes, etc. to get to 15") and marked as B. Now measure another 60 degree angle and another six feet to establish "Zone C" which is 40" off the ground.



Your Ninja Walk score is based on two variables:

Sample Ninja Walk

Y (Acceleration) Live	1.18 m/s ²
Y Average	1.10 m/s ²
Y High Value	1.34 m/s ²
Y Low Value	0.77 m/s ²
Z (Gravity) Live	9.68 m/s ²
Z Average	9.70 m/s ²
Z High Value	10.11 m/s ²
Z Low Value	9.34 m/s ²
Your Ninja Walk final score averages acceleration on the Y axis while holding your device level for this final, big challenge!	
Acceleration:	75.66 %
Level:	94.23 %
Final Ninja:	84.94 %

- Your Ninja Walk score combines your ability to stay level (determined by **gravity** on your Z axis) and how well you can move with zero **acceleration** on the Y axis. Monitor these numbers as you practice the course.
- Your final score, shown in yellow, is calculated as a percentage based on your performance on both of these variables.

Good luck Ninja!

You may want to use tape to mark off the sides of the triangle to make it easier to follow.

1. In Vizeey, click on Ninja Walk to load the experiment.  **4. Ninja Walk**
PH | Ninja Walk | Experiment
2. Ninja Walk is a 15 second timed Experiment. This timed run gives you a 3 second delay to prepare then starts the timer!
3. Conduct several practice runs as described in the rules below to prepare for your final, "best Ninja" moves!
4. Use   to start and to pause the experiment.

Rules

- Begin your timed run with your device resting on point A (you must pick it up from the table or surface it is resting on).
- Your device must pass directly over point B and C - no shortcuts!
- Finally, your device must be set back down on point A to conclude the run!
- Once set down, let the timer run out and conclude your experiment.

How close were you able to get to 100%? Share with your friends to see who can master the best Ninja walk.

Challenge

With your newfound knowledge of **acceleration** and **gravity**, create your own course that will optimize your 15 second Ninja Walk score. Your only requirement is that the course is 18 linear feet in any configuration.

Further Exploration

Now that you have been introduced to the concept of **acceleration** conduct further studies using the **accelerometer** to deepen your understanding. How can you explore **acceleration** further? Be creative - go forth and explore!

Vizeey™ Extension

Pretend that you need to explain the force of **gravity** and **acceleration** to someone. Draw visual representations to explain both concepts.

Check for Understanding

- How can **acceleration** be zero when you are moving?
- What is the value of **acceleration due to gravity** in meters per second squared?
- What is an example of **balanced forces**?