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| **Title** | **Impacting the risk of falling: How do Accelerometers work?** |
| **Introduction** | Injuries due to falling are an important health concern in the US. According to the National Institute of Health, falls are the most common accident in individuals over the age of 65. In the year 2010 there were 4.1 deaths per 100,000 people per year in the country. In this Problem Based Learning Activity students will explore the physics behind center of gravity and tipping point as they seek to understand the mechanisms behind people losing their balance. Students will explore the One Health Initiative and experiment with accelerometers to learn how researchers in the ASSIST (Advanced Self-Powered Systems of Integrated Technology) program are working to design wearable self-powered devices that can prevent accidents and illness.  Students will work with accelerometers that can be found in the TI sensor tags, on iPads, on most cell phones, etc. In this lesson the accelerometer the students will use is the SparkView application from PASCO and the accelerometer that is built into their ios device. Students will experiment, collect and analyze data and determine thresholds for falling. At the end of the project each group of students must be able to explain how their accelerometer works. Each group must also show how they have visualized and analyzed the data to determine accelerometer readings that will indicate situations where the person is capable of falling. Students will prepare a lab report at the end of the project and present their findings to the class.  Students will be taught using the modeling pedagogy. Students will work in groups on the activities and report out using small group whiteboards. Each day will end in a discussion of the whiteboards and students will be encouraged to question each other and ask for clarification of ideas from the teacher. The teacher’s role in this PBL unit is the facilitator of learning. |
| **Real Science Application (If Applicable)** | The One Health Initiative is striving to develop solutions to animal, human and environmental health problems across the globe. Physicians, veterinarians, engineers, and scientists are working together to solve world health problems. You may visit the One Health Initiative website to learn more about this topic. <http://www.onehealthinitiative.com/>  Accelerometers can provide a lot of useful data about movement. Many electronic devices such as cell phones, tablets and wristbands contain built-in accelerometers. These accelerometers are used to track the user’s mobility and the devices motion throughout the day.  Accelerometers are mechanical devices that measure the acceleration forces on an object. The force of gravity is the pull of the mass of the earth downward on a body. Moving the accelerometer causes forces to be measured in three dimensions as related to the downward force of gravity. This is the object’s tilt with respect to the ground. The iPad and iPhone (and many android devices) have accelerometer sensors built-in to their circuit boards. These accelerometers enable the screens on these devices to rotate between portrait and landscape mode. Companies have begun to write apps that use these built-in accelerometers for purposes other than screen rotation. PASCO has an app called SparkVue that is free to download and uses the on-board accelerometers, microphone, and front and back cameras to collect data. This is the accelerometer that the students will use in this lesson. It is a three axis accelerometer and you can find out the generalities of how it works from the engineerguy.com at [http://www.engineerguy.com/elements/videos/video-accelerometer.htm](%20http:/www.engineerguy.com/elements/videos/video-accelerometer.htm). |

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| **Curriculum Alignment** | |  |  |  |  | | --- | --- | --- | --- | | Content Area | Grade Level | NC Essential Standards | NGSS | | Physics | 10-12 | Phy. 1.1 Analyze the motion of objects | HS-PS2-1 Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. | | Physics | 10-12 | Phy.1.2 Analyze systems of forces and their interaction with matter |  | | Engineering Design II | 10 |  | ED2.1.01 Develop the abilities necessary to do and understand scientific inquiry as it relates to science and engineering.  ED2.1.02 Understand how science and engineers work.  ED2.1.03 Understand that engineering design is a creative and iterative process for identifying and solving problems in the face of various constraints.  ED2.1.04 Understand the role of mathematics in science and engineering..  ED2.1.06 Understand and implement the Engineering Design Process for creating prototypes and models.  ED2.3.01 Develop, construct, and evaluate solutions to issues using systems thinking and applying and using scientific knowledge. | |
| **Learning Outcomes** | Participants will understand how an accelerometer works.  Participants will have a working understanding of the concepts behind the One Health Initiative.  Participants will be able to use an accelerometer to collect meaningful data.  Participants will be able to graphically analyze their accelerometer data and determine tipping points.  Participants will be able to support their conclusions about the point of falling with data they have collected and analyzed. |
| **Time Required and Location** | 90 minute class period on day 1 in the classroom.  90 minute class periods on day 2, 3, and 4 in the classroom/lab room.  3-5 weeks of One Health project development for competition after this introductory unit. |

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| **Materials Needed** | Teacher List   * SparkVue app directions tutorial at <https://www.youtube.com/watch?v=YkBJmH1F2aU> * SparkVue application downloaded to the devices: Itunes <https://itunes.apple.com/us/app/sparkvue/id361907181?mt=8>, Google Play <https://play.google.com/store/apps/details?id=com.isbx.pasco.Spark&hl=en>, Chrome Web Store <https://chrome.google.com/webstore/detail/sparkvue/iimbdmgkimpbhimdjnmiffmeefbppijo?hl=en> * iPads for each group of students or let each group use an iPhone, tablet or other android device. The program also runs on Chrome Books.   Student List   * iPad, iPod, Chrome Book, android tablet or phone with the SparkVue application downloaded * 3 foot square whiteboards for reporting out each day and class discussions * Data collection notebook * Student email account * Whiteboard markers |
| **Safety** | Safety concerns are limited to the correct use of the iOS, chrome books, or android devices. Students should be reminded to avoid dropping their devices. There are no chemicals in this activity***.*** |
| **Participant Prior Knowledge** | These activities are designed to be part of a larger One Health Design project. Students should understand the physics principles of Newton’s Laws of motion. Students need to know how to calculate gravity using Newton’s second law, F=ma. Students should understand slope of graphs and what the area under a graph of acceleration versus time equals the velocity of the object. Students should be able to use spreadsheets to graph data sets. |
| **Facilitator Preparations** | * Become familiar with the SparkVue lab application from PASCO. There are many tutorials available on the web. * If necessary, reserve computers. iPads, or iPods for this lesson. * Download the videos to your presentation computer ahead of time if your school has connection problems. * Assign the download of the application (if students are using their own devices) as homework at least two nights before you are starting the accelerometer data collection. * Group students into groups of two to four. * Designate lab space for each group where the students can move around with the equipment. |
| **Activities** | **Day 1: Engage:**  Start the lesson by showing the class the video about One Health: From Idea to Action <https://www.youtube.com/watch?v=gJ9ybOumITg> [3 minutes]  Pair up the students and have each group list the 5 ideas about One Health that they learned from the short video. [5 minutes]  Show the students the infographic that depicts the various topics covered under the One Health Initiative. The picture can be located at [https://www.google.com/search?q=one+health+initiative&espv=2&biw=1305&bih=735&source=lnms&tbm=isch&sa=X&ved=0CAcQ\_AUoAmoVChMI5beR2PXYxgIVC1WSCh2NxQlV#imgrc=oLOeBssVmM1sbM%3A](https://www.google.com/search?q=one+health+initiative&espv=2&biw=1305&bih=735&source=lnms&tbm=isch&sa=X&ved=0CAcQ_AUoAmoVChMI5beR2PXYxgIVC1WSCh2NxQlV%23imgrc=oLOeBssVmM1sbM%3A)  Present the video “Fear of Falling” <https://www.youtube.com/watch?v=RU5KW5ZoXrY> and tell students that they are going to use physics to help solve this problem. [approx 3 minutes]  Present the Activity Problem: How can accelerometer data help prevent falls among elderly people?  Ask students to work with their partner and make a list on their whiteboards of everything that they know about falling. Each group should also list on their whiteboards facts that they know about acceleration and accelerometers.  Explore:  Ask “ Do you understand how your phone or iPad knows to rotate the screen when you rotate the device?  Allow the students to experiment with rotating the devices. Tell each student to take a turn rotating the device. [3 to 4 minutes]. Ask them to speculate on the mechanism that enables the screen to rotate.  After walking around and discussing the screen rotation with the students give the students the hand-out about accelerometers and their uses. Allow ample time for students to read the handout.  History of the accelerometer Journal Article: <http://www.sandv.com/downloads/0701walt.pdf> SOUND AND VIBRATION/JANUARY 2007  Assign the reading for homework and ask the students to:  1. make a list of applications for accelerometers  2. explain in their own words how accelerometers work  3. list the types of data an accelerometer can collect  4. list the laws of motion that can be supported with the accelerometer data  On day 2 start the class with a discussion of these homework questions.  **Day 2: Explore/Explain**  Start the class with a discussion of day 1’s reading on accelerometers.  Students should be able to elaborate on each question and have a basic understanding that accelerometers give data based on the equipment’s movement toward or away from earth’s gravity.  After finishing the homework discussion divide the students into groups of 2 to 4. Group size is dependent upon how many iPads you have.  Give each group an iPad and tell them to open the SparkVue app.  Hand each group the Measuring Acceleration with SparkVue handout. This handout will get the groups started with the app. Encourage students to see what kinds of accelerometer data they can collect. Let the students explore the app on their own.  You may wish to make the PASCO SparkVue manual available for students. The manual goes into all the details about the app. However, the handout will get them started.  <http://www.pasco.com/file_downloads/product_manuals/SPARKvue/SPARKvue-2.2-English-Users-Guide-PS-2400-PS-2401.pdf>  **This is the SparkVue Handout Directions:**  Measuring acceleration with SparkVue  This document will get you started with the app.   1. Open the SparkVue app on the iPad 2. You will see a list of sensors. You will be using the On-board Acceleration Sensor for this activity. 3. You must “build” your data collection page before you can start to collect data.    1. Tap the “build” button. It will be highlighted at the bottom of the iPad screen.    2. You will see a lot of templates. Choose the sixth one from the list. The template that is divided equally in half.    3. Select the graph tool to be the left side and the “1.23” (numerical display) to be your right side. 4. Now that you have the tools selected you must select measurements.    1. Let time be your x axis.    2. Tap “select measurement” on the y axis and you will see a new screen. Under vertical axis, tap the “measurement” button and select “acceleration, x”. This will allow you to measure horizontal acceleration. You will repeat this procedure when you want to measure acceleration in other directions. (You may also add other vertical axes. Determine if your group would like to do this in later data runs).    3. Tap “OK” when you have your Line Graph Properties set.    4. Now you must select the measurement for your digital readout (right side) window.    5. Tap “select measurement”. Start your data collection with “acceleration, x”. Change these measurement parameters as you experiment with the accelerometer.    6. Units for the y axis and the digital readout should be in m/s/s. 5. The green arrow will start your data collection. 6. Run a few trials to get comfortable collecting the data and moving the accelerometer. Remember that you will need to test many different scenarios to solve your problem. 7. When you are finished with a trial tap the now orange arrow and data collection will stop. 8. To start collecting more data with the same parameters, simply tap the green arrow again. New data will be recorded on the screen in a different color. You can tap to highlight the runs that you want to analyze so that you can see them one at a time. 9. You can export data by tapping the triangle icon (share icon) at the top of the screen. Under Online Storage services you have several choices including Google and Dropbox. You also can email the data to yourself if the iPad is set up to do this. Files may also be saved to the iPad. 10. Analyzing the data.     1. The SparkVue app has many statistical analysis tools. You can access them by tapping the graph icon that is directly under the graph on the screen.     2. You can select to analyze runs individually or together.   Additional Information:  You may access the SparkVue manual at <http://www.pasco.com/file_downloads/product_manuals/SPARKvue/SPARKvue-2.2-English-Users-Guide-PS-2400-PS-2401.pdf>  Student groups should start to develop their testing/experiment protocols.  Students should plan with their whiteboards. Circulate among the groups and answer procedure questions and give guidance.  Data collection should start today. There are multiple ways that students can analyze the data if the Sparkview app does not work in your classroom. This is an app for an iPhone.  Video: Accelerometers and How they work : <http://www.livescience.com/40102-accelerometers.html>  \*\* students should download and use the SensorLog app by Bernd Thomas to capture and analyze the data from their devices. “With SensorLog you can read out sensor data of your iOS device and send it via email as csv file, stream it via tcp/ip, and send it via HTTP GET/POST request.”  Students can email data to their email accounts, share to Google Drive, Box, Dropbox, FTP, and WebDAV. Data can also be saved on the iPad.  In summary, on day 2 students should begin to develop their experiment protocol and gathering data with the SPARKVIEW or other app.  **Day 3: Elaborate**  Students should spend this day gathering data from the iPad accelerometer and working in their groups to determine the parameters for falling.  \*\*(Alternative to Sparkview app) students should download and use the SensorLog app by Bernd Thomas to capture and analyze the data from their devices. “With SensorLog you can read out sensor data of your iOS device and send it via email as csv file, stream it via tcp/ip, and send it via HTTP GET/POST request.”  Remind students that the data they collect must support their conclusions.  You should direct students to the lab report rubric for reference. (Lab rubric located at the end of this lesson)  Each group should prepare to share their procedure, data, results, and conclusions with the class on day 4.  At the end of this day students should have designed an answer to the essential question. “How can accelerometer data help prevent falls among elderly people?”  **Day 4: Evaluate**  Please see the assessment section of this document for the evaluation piece. Students can use the multiple representation target found at the end of this lesson as a guide for their data presentation and to compliment their lab report. |
| **Assessment** | Rubrics will be used for assessing the collection and the interpretation of the lab data in this lesson. This will occur after day 4 of the lesson.  Student whiteboards will be structured and assessed using the TARGET template. Students should be able to graph, use words, have a data table, and use symbols to explain what they have learned. An example TARGET is at the end of this document.  For the final product the students will complete a lab report. The rubric is in this document. A focus of the lab report is on the analysis and interpretation of the accelerometer data. Question students to be certain that they understand what the data represents.  See the following rubrics at end of the unit plan: (Rubrics were attached as noted here)  1. Target Template (example below) TARGET at the ends of this document  2. Rubric One Lab Write-Up (Lab report rubric at the end of this document) |

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| **Critical Vocabulary** | Accelerometer: an instrument for measuring acceleration or for detecting and measuring vibrations.  Acceleration: the rate at which the speed of a moving object changes over time  One Heath Initiative: a global movement to forge collaboration between all medical disciplines, veterinarians, environmentalists, and government to ensure the health of humans, animals and the environment. |
| **Community Engagement** | * Speakers from the NCSU ASSIST center * Participants will enter a One Health competition in the spring semester that is sponsored by the NCSU ASSIST Center |
| **Extension Activities** | Students can use the SparkVue app and the iPad to develop parameters to decrease titling in mobility assisted devices such as wheel chairs and scooters. |
| **Modifications** | Create specific groupings of students for this activity especially if they have difficulty reading the SparkVue instructions on the handout.  Include video clips of how to use the SparkVue. Some examples of the video directions can be found at <https://www.youtube.com/watch?v=oQznZkayVac> |
| **Alternative Assessments** | Participants can prepare a multimedia presentation instead of a lab report. |
| **References** | Assess the SparkVue manual at <http://www.pasco.com/file_downloads/product_manuals/SPARKvue/SPARKvue-2.2-English-Users-Guide-PS-2400-PS-2401.pdf> |
| **Comments** | This lesson plan is part of a larger unit where the students will design a wearable sensing device for a competition in the spring semester. Students will receive a lot more background information in other parts of the PBL wearable device unit. The entire unit will take about six weeks of students working two days of week on their devices. Currently the competition runs in early April and students are allowed to start work in late January. These dates are subject to change. |
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