Accelerations in the Real World

The portability of the data-collection equipment makes it ideal for studying accelerations that occur outside the physics laboratory. Some interesting situations are the automobile and amusement park rides, as well as high-speed elevators, motorcycles, and go-carts.

An accelerometer measures the acceleration in a specific direction. You will need to choose an appropriate time scale and the direction in which to hold the Accelerometer to obtain meaningful information. Obtaining acceleration data from independent kinematics measurements can transform an informal study into an empirical evaluation of a mathematical model.

This lab highlights several situations where you can collect real-world acceleration data. A general procedure is given that you will modify depending on which study is performed. After the general procedure, you will find several suggestions for acceleration investigations. You will need to plan an experiment around the motion to be studied, adjusting data-collection parameters as needed.

OBJECTIVES

- Measure acceleration in a real-world setting.
- Compare the acceleration measured to the value calculated from other data.

MATERIALS

LabQuest
LabQuest App
Vernier Low-g Accelerometer **or** Wireless Dynamics Sensor System (WDSS)

SET UP PROCEDURE

Using a Low-g Accelerometer

The following steps will guide you through configuring LabQuest to collect acceleration data with a Low-g Accelerometer. You will probably need to modify either the time between samples or the number of points collected for your particular circumstances. Adjust these values as you design your experiment.

1. Connect the Low-g Accelerometer to LabQuest and choose New from the File menu.

2. On the Meter screen, tap Rate. Change the data-collection rate to 10 samples/second and the data-collection duration to 20 seconds. You may want to use different values according to your experimental conditions.

3. Zero the Low-g Accelerometer in the orientation you plan to collect data. For example, if the Accelerometer is to be oriented horizontally during data collection, place the sensor on a horizontal surface with the arrow horizontal. Or, if you will be collecting data with the sensor oriented vertically, then place the sensor against a vertical surface with the arrow vertical.
   a. Orient your Low-g Accelerometer as appropriate for your experiment.
   b. Choose Zero from the Sensors menu. When the process is complete, the readings for the sensor are close to zero.
4. Start data collection when you are ready to collect data.

5. When data collection is complete, a graph of acceleration *vs.* time is displayed. To examine the displayed graph, tap any data point. Acceleration and time values will be displayed to the right of the graph.

Using WDSS

The following steps will guide you through configuring a WDSS to collect acceleration data with an internal accelerometer. You will set up the WDSS to stream data to LabQuest using Bluetooth technology and then analyze the data in LabQuest App. You will probably need to modify either the time between samples or the number of points collected for your particular circumstances. Adjust these values as you design your experiment.

1. Turn on the WDSS. Note the name on the label of the device.

2. Choose New from the LabQuest App File menu. Choose WDSS Setup from the Sensors menu.

3. Tap Scan to look for WDSS devices.

4. Select your WDSS and select OK.

5. Select the accelerometer in the orientation you plan to collect data. For example, if you will be collecting data with the WDSS oriented vertically, select Accel-X.

6. On the Meter screen, tap Rate. Change the data-collection rate to 10 samples/second and the data-collection duration to 20 seconds. You may want to use different values according to your experimental conditions.

7. Zero the Accelerometer in the orientation you plan to collect data.
   a. Orient your Accelerometer as appropriate for your experiment. For example, if you will be collecting data with the sensor oriented vertically, then place the WDSS against a vertical surface with the x-axis arrow pointed upward.
   b. Choose Zero from the Sensors menu. When the process is complete, the readings for the sensor are close to zero.

8. Start data collection when you are ready to collect data.

9. When data collection is complete, a graph of acceleration *vs.* time will be displayed. To examine the displayed graph, tap any data point. Acceleration and time values will be displayed to the right of the graph.

AUTOMOBILES AND MOTORCYCLES

Part I Linear Acceleration on a Straight Road

The accelerometer and LabQuest can record the acceleration of a motor vehicle. A good motion to study is speeding up from rest, followed by slowing to a stop. Initially set up data collection for a duration of 30 seconds, although you may find that this time should be shortened or extended. Zero the Accelerometer with the arrow held horizontally.

Place the accelerometer in a horizontal direction with the arrow of the accelerometer aligned with the direction of the motion. Start data collection just before starting the vehicle. Accelerate to a safe speed, and then slow to a stop. Keep the vehicle moving in a straight line and keep it on a level section of roadway for this experiment.

Ask the driver to maintain a constant acceleration while speeding up, as well as a constant acceleration when slowing down. Compare different vehicles; compare acceleration patterns with automatic and manual transmissions. For an independent acceleration measurement, collect velocity *vs.* time data during the trial, either by calling out times and recording the instantaneous velocities, or perhaps by collecting video of the speedometer. Compare the accelerations you obtain with the accelerations that are recorded by the interface.

Part II Centripetal Acceleration in Corners

When a vehicle turns a corner, a centripetal acceleration is present. By placing the axis of the accelerometer horizontally and perpendicular to the forward direction, you can record the accelerations in curvilinear motion. Initially set up data collection for a duration of 30 seconds, although you may find that this time should be shortened or extended. Set up a path that has several curves of measured radii as well as straight sections. A parking lot not used on weekends would be best. Practice until the driver can maneuver through the course while maintaining a steady speed. Place the accelerometer in the horizontal direction so it is stable relative to the vehicle and perpendicular to its motion, arrow pointing to the inside of curve. Accelerate to the planned speed and keep the vehicle moving at a constant speed. Start data collection just before entering the test section containing the curves.

For an independent acceleration measurement from kinematics, you will need to know both the radii of the turns and the speed of the vehicle.

ELEVATORS

Take LabQuest and the accelerometer to a building that has a high-speed elevator and a height of six stories or more. Zero the accelerometer with the arrow vertical. Initially set up data collection for a duration of 90 seconds. You will want to adjust this time depending on the transit time of your elevator.

Enter the elevator and place the accelerometer against the elevator wall with its arrow pointing upward. Do not hold it in your extended hand because the motion of your arm will change the acceleration measurement.

Program the elevator to stop at two floors on the way up, then program it to stop at two floors on the way back down. Start data collection when the doors close on the elevator.

Optional: If you can determine the height of a single story, you can collect data on floor-number *vs.* time to obtain velocities while the elevator is ascending or descending. You can use a video recording to measure this. Compare the velocity you obtain this way with the area under the acceleration *vs.* time graph.

AMUSEMENT PARKS