

# Physics With Video Analysis

Files for Vernier Video Analysis® and Vernier Graphical Analysis Pro®

## Introduction

The activities in the book *Physics with Video Analysis* were written to use *Logger Pro*® software, making extensive use of pre-made files distributed with the software. If your students are using Chromebooks or tablets, or if *Logger Pro* is not available, you need to use our Vernier Video Analysis and Vernier Graphical Analysis Pro apps. The Vernier Video Analysis and Vernier Graphical Analysis Pro files included with this download can be used to do the *Physics with Video Analysis* activities.

**Note:** Student instructions (PDF files) are not included with these files. Owners of the book can access those files using their Vernier Web account or from the CD that came with the book. There are no plans to update the student instructions.

There are several ways in which activities from this book use videos for data collection and analysis. While *Logger Pro* supported all these options, you will need both Vernier Video Analysis and Vernier Graphical Analysis Pro to do all the activities from this book.

**Analysis of an object's motion**—use Vernier Video Analysis  
Activities: 1, 3, 5–9, 11–16, 18–20, 22, 23, 25–27

**Analysis of sensor data synced with a video**—use Vernier Graphical Analysis Pro  
Activities: 4, 17, 21, 23, 24, 29, 31, 32



**Manual entry of data obtained from a video**—use Vernier Graphical Analysis Pro  
Activities: 10, 28–31, 33

**Analysis of an image (or single video frame)**—use Vernier Video Analysis

- Making distance measurements  
Activities: 2, 29
- Marking multiple points  
While Vernier Video Analysis does not supported this feature, a video having multiple frames of a single image can be used to achieve the desired results.  
Activity: 21

Other differences in features and functionality between the *Logger Pro* files and the included Vernier Video Analysis (VBML) and Vernier Graphical Analysis Pro (GAMBL) files that impact the activities are noted on the pages that follow.



## General Information – all activities

- Nonessential data columns were hidden in the *Logger Pro* data tables. Vernier Video Analysis and Vernier Graphical Analysis Pro cannot hide data columns. Because of this, and to reduce clutter on the screen, the data table is not shown in most of the files. Use View Options, , to show the data table when needed.
- In *Logger Pro*, the first frame of a video is frame 0. In Vernier Video Analysis, the first frame is frame 1. Because of this, references to specific frame numbers will be off by one.
- The last frame of most videos is a duplicate of the preceding frame. This extra frame was added to address a *Logger Pro* issue that prevented the last video frame from displaying on Windows computers. Because of this, the right Video Range Indicator, , is often set to prevent this frame from showing automatically in Vernier Video Analysis.
- Vernier Graphical Analysis Pro files that have sensor data synced with the video include a column “LT” with values 0 Lux. This column should be ignored.


**Note:** To sync data to a video in Vernier Graphical Analysis Pro, a time column created from live sensor data collection is required. (A manually added column named Time cannot be used for this purpose.) To create the column, data from a light sensor was collected using the same rate and duration used for the sensor data included in the original *Logger Pro* file. Once the time column was created, data from the original file was added to the new file using manual columns.

## Activity Specific Information




### 03 Velocity Change

- To replay the video synced with the plotted data, click or tap Enable Replay, , set the Playback Speed Multiplier to **0.422**, then click or tap Play replay, .


### 04 Velocity Speed

- To view the plotted data, replay the data-synced video by clicking or tapping Play replay, .
- The *Logger Pro* file used a second page within the file to show additional graphs. Vernier Graphical Analysis Pro does not support multiple pages. To address this, a second data file was created.
  - <VelocitySpeed.gambl> for Activity-Based Questions 2(a) – 2(h).
  - <VelocitySpeed-Pg2.gambl> for Activity-Based Question 2(i).


### 05 Velocity Acceleration

- To replay the video synced with the plotted data, click or tap Enable Replay, , set the Playback Speed Multiplier to **1.0**, if necessary, then click or tap Play replay, .
- The data table, shown on page 2 of the *Logger Pro* file, is not shown in the Video Analysis file. Use View Options, , to show the data table if needed.

## 07 Demon Drop

- Activity-Based Question 2(d), **Check the model**, instructs students to use the Modeling feature in *Logger Pro*. This feature is not available in Vernier Video Analysis. Students can test their models using a custom curve fit as described below.
  1. Click or tap Graph Options, , and select **Apply Curve Fit**.
  2. Choose the general curve fit model you think matches the data (e.g., proportional, linear, quadratic, etc.).
  3. Choose **Create Custom Fit** and give your fit a name (e.g. Demon Drop Fit).
  4. Modify the Fit Expression to include the coefficients you identified for your model, then add a new fit parameter, “+ h”. For example, if your selected model was quadratic (i.e.,  $ax^2 + bx + c$ ) having coefficients  $a=3$ ,  $b=5$ , and  $c=8$ , your modified Fit Expression would be  **$3x^2+5x+8+h$** .
  5. If your model is a good fit, the fit line will visually match the data, and the fit parameter, **h**, will be close to zero.
  6. To try a different model, repeat the above steps as needed.


## 08 Moon Jump

- Activity-Based Question 2(b) has students set the Time Offset in *Logger Pro*. This feature is not available in Vernier Video Analysis. Because of this, the left Video Range Indicator, , has been set to restrict the video to start at time  $t = 0.5$  s. This makes the time associated with a point marked on this frame  $t = 0$  s.
- Activity-Based Question 2(c) has students check their model from the previous step. See activity **07 Demon Drop** notes shown above for instructions on how to do this.


## 10 Galileo Then

- While there was no *Logger Pro* file for this activity, we have included a Vernier Graphical Analysis Pro file, <GalileoThen.gambl>, that includes the embedded video and a data table that can be used to record both the predicted and measured landing positions.


## 11 Galileo Now

- Activity-Based Question 2(b) has students set the Time Offset in *Logger Pro*. This feature is not available in Vernier Video Analysis. Because of this, the left Video Range Indicator, , has been set to restrict the video to start at time  $t = 0.63$  s. This makes the time associated with a point marked on this frame  $t = 0$  s.

## 14 Juggler

- Activity-Based Question 2(b) has students set the Time Offset in *Logger Pro*. This feature is not available in Vernier Video Analysis. Students can use the left Video Range Indicator, , to restrict the video to start at Frame 16 ( $t = 0.50$  s) before they start marking points. This makes the time associated with a point marked on this frame  $t = 0$  s.

## 16 Spring Constant

- Only one of the two graphs used in this activity is shown when the file is opened. Use View Options, , and choose **2 Graphs** to view the second graph, F\_y vs. Y.

## 17 Net Work and Kinetic Energy

- The Logger *Pro* file used a second page within the file to show additional graphs. Vernier Graphical Analysis Pro does not support multiple pages. Instead, a second Vernier Graphical Analysis file is included for those graphs.
  - <NetW-KE.gambl> for Preliminary Question 1(e) part 1.
  - <NetW-KE\_Pg2\_Analysis.gambl> for Preliminary Question 1(e) part 2 and beyond.


## 18 Oscillations

- Two of the Logger *Pro* files included a parameter, VA\_Angle, to control the rotation of the axes used for video analysis. Vernier Video Analysis does not support this feature.
  - For Activity Based Questions 2(d) and 2(e), instruct your students to manually rotate the axes using the Origin tool.
  - For Activity Based Question 2(q), instruct students to manually rotate the axes using the Origin tool until the X\_circle graph resembles a graph of sin(t).
  - For Activity Based Question 2(r), if students have trouble manually returning the axes back to its starting orientation (i.e., VA\_Angle = 0), have the students reopen the file <Oscillations-2.vmbl>.

## 19 Wave Speeds

- Preliminary Question 1(a) references specific video frames by number. Because of the differences in how the first frame is numbered, the frames referenced in this question all need to be increased by 1. (e.g., Logger *Pro* frame 14 is Vernier Video Analysis frame 15.)

## 21 Wave Pulse Equation

- For this activity, both Vernier Video Analysis and Vernier Graphical Analysis Pro are used.
  - Activity-based Questions 2(a) and 2(b) refer to Vernier Video Analysis file <WaveCrestVelocity.vmbl>.
  - Activity-based Questions 2(c) and beyond, refer to Vernier Graphical Analysis Pro file <ImageAnalysis.gambl>.
- Activity-based Question 2(c) has students test various curve fit models to match the shape of the wave crest. The instructor notes identify a Gaussian curve as the preferred model. Since Vernier Graphical Analysis Pro does not include the Gaussian curve fit model, students will need add that curve fit model manually.
  1. Click or tap Graph Options, , and select **Apply Curve Fit**.
  2. Choose the Natural Exponent curve fit model, then click or tap **Create Custom Fit**.
  3. Modify the Fit Expression as follows:  **$a \exp(-(x-b)^2/c^2) + d$** .
  4. Name the fit **Gaussian**, then click or tap Apply.

- Activity-based Question 2(e) has students view a second page of the Logger *Pro* file. Since Vernier Graphical Analysis Pro does not support multiple pages, students will need to manually change what is shown in the <ImageAnalysis.gambl> file as follows:
  - Advance the video to the end, showing the image of the Frame 20 wave crest.
  - Use the y-axis plot manager to show the Frame 20 wave crest data.
- The Vernier Video Analysis file <ImageAnalysis\_Optional.vmb1> contains a specially made video having ~60 frames each of the two wave crest images (from Frames 1 and 20).
  - Use this file (instead of the <ImageAnalysis.gambl>) if you want your students to manually mark the shape of the wave crests.
  - Students should mark each coil of the spring for the crest portion of the wave.
  - Students need to switch **Objects** before marking points on the Frame 20 wave crest.


## 23 Doppler Sound

- For this activity, both Vernier Video Analysis and Vernier Graphical Analysis Pro are used.
  - Activity-based Questions 2(b) refers to Vernier Video Analysis file <CarSpeed.vmb1>.
  - Activity-based Questions 2(d) refers to Vernier Graphical Analysis Pro file <FrequencyShift.gambl>.
- In the <FrequencyShift.gambl> file, the graphs are set up as follows:
  - Graph 1 is the sound data.
  - Graph 2 is the FFT analysis applied to the sound data between  $t = 0$  and  $t = 1$ .
  - Graph 3 is the FFT analysis applied to the sound data between  $t = 2$  and  $t = 3$ .

## 24 Heat Engine

- The Logger *Pro* file used a second page within the file to show additional graphs. Vernier Graphical Analysis Pro does not support multiple pages. Instead, a second Vernier Graphical Analysis Pro file is included for those graphs.
  - <HeatEngine.gambl> for Getting Started and Qualitative Considerations Questions.
  - <HeatEngine-Pg2\_PVgraph.gambl> for Comparison of Work Done Question 2(b).

## 26 Discharge Rate

- The Logger *Pro* file showed three graphs; Vernier Video Analysis can only show two graphs. Students need to use View Options, , and the plot manager tools to set up the additional graphs used for Activity-Based Questions 2(f) and 2(g).

## 28 Ohm's Law

- The Logger *Pro* file included two videos. Vernier Graphical Analysis Pro does not support multiple videos in a single file. Instead, a special video file <Resistance\_Bulb+Resistor> was created for use with this activity. The new video was made by appending the resistor video to the end of the light bulb video. The resistor portion of the video starts at  $t = 13.50$  s.

- In Activity-Based Question 2(a), students are instructed to use specific video frames when recording data. Vernier Graphical Analysis Pro does not show video frame numbers. Instead, students should be instructed to use the following movie times when recording the current and voltage drop data:

**Bulb**

Frame 0, time = 0 s  
Frame 26, time = 5.30 s  
Frame 43, time = 8.75 s  
Frame 64, time = 12.90 s

**Resistor**

Frame 0, time = 13.50 s  
Frame 28, time = 18.9 s  
Frame 48, time = 22.75 s  
Frame 73, time = 28.30 s

## 29 Capacitor Spacing

- For this activity, both Vernier Graphical Analysis Pro and Vernier Video Analysis are used.
  - Activity-based Questions 2(a) refers to Vernier Graphical Analysis file <StorageDataSet.gambl>.
  - Activity-based Questions 2(b) refers to Vernier Graphical Analysis Pro file <V\_r vs d.gambl>.
  - Activity-based Questions 2(c) requires Vernier Video Analysis file <PlateArea.vmb>.

## 30 Capacitor Network

- While there was no Logger *Pro* file for this activity, we have included a Vernier Graphical Analysis Pro file, <Capacitors.gambl>, that includes the embedded video and a data table for recording the capacitance values for the various combinations of capacitors.