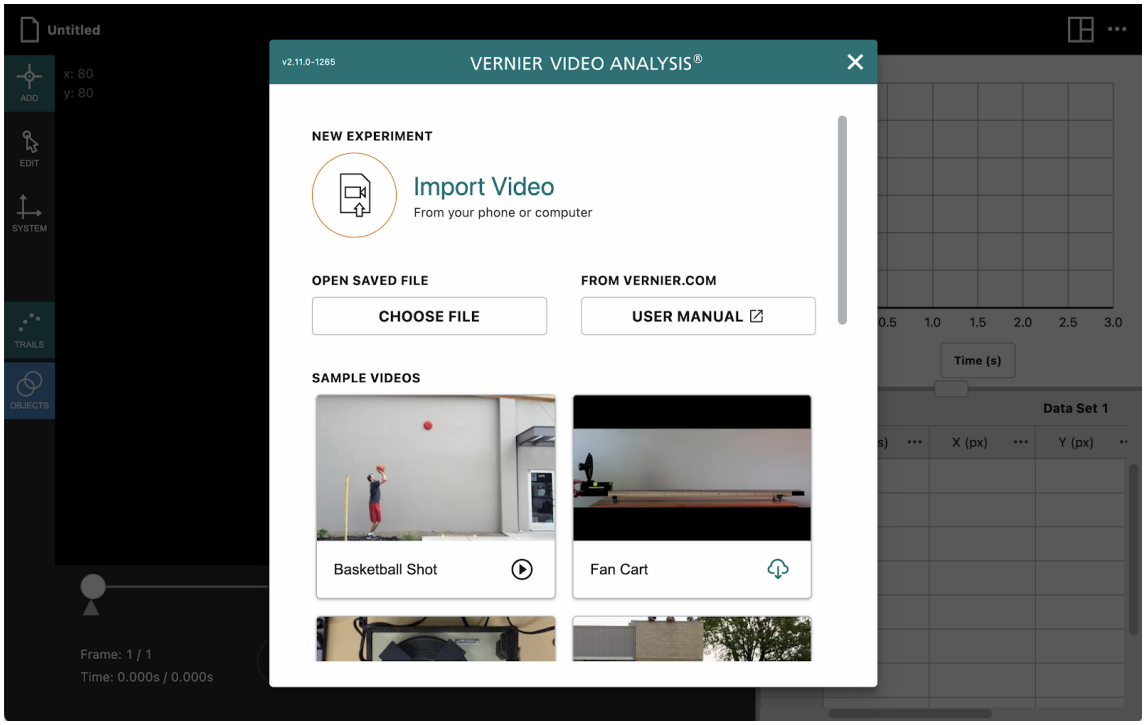
Vernier Video Analysis®
User Manual



Version 2.11
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Vernier®
SCIENCE EDUCATION

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ABOUT THIS GUIDE

Vernier Video Analysis is a tool for science students to analyze the motion of real-world objects in videos. Students use dots to mark the position of objects in successive frames of video. When a scale and axes are defined, the app assigns each point spatial coordinates. These spatial coordinates are used with the time (based on frame number) to calculate vertical and horizontal velocities. This document reflects features available in Vernier Video Analysis v2.11.0.

I. Getting Started with Vernier Video Analysis

Compatible Browsers and Platforms

The Vernier Video Analysis app runs in a browser. As a sophisticated application using many advanced calls in a browser, Video Analysis requires a nearly current version of compatible browsers. Vernier Video Analysis is designed to run in Chrome™, Firefox®, Edge, and Safari® browsers.

Because Vernier Video Analysis is updated frequently, and updates are automatically distributed to users, Video Analysis requires that the browser be up to date (most recent version or one version older only). Unless actively blocked, browsers generally update automatically in order to maintain security patches. You can determine current browser versions at https://www.whatismybrowser.com/guides/the-latest-version

Activate Vernier Video Analysis

After purchasing a license for Vernier Video Analysis, you will receive an activation code in an email from info@vernier.com. Once you have your activation code, log in to your account at www.vernier.com/account. Use the activation code to begin your license term and receive a license key. The license key is embedded in a URL that will allow you to directly access the authenticated app, eliminating the need to enter the license key when you open the app.

The best way to access Vernier Video Analysis is to use the provided URL with embedded license key, as no additional authentication is needed. The alternate method is to browse to videoanalysis.app and enter your license key. In either case, you should immediately see the welcome screen as shown in Step 1.

The primary URL for access once activated is videoanalysis.app

TIP! *It is useful to bookmark this URL for easy access.*

Activation information for Vernier Video Analysis is stored in browser files. If the browser files are cleared, or if a different browser is used, the activation screen will be displayed. The activation screen will also appear the first time a given device opens the app, or if more than two weeks has elapsed since last opening the app while connected to the internet.

Site License Terms

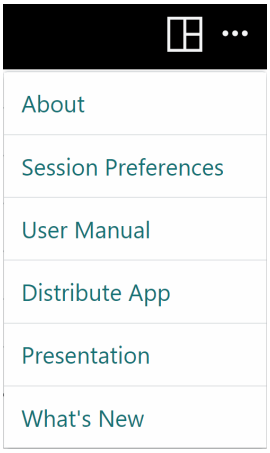
A purchased site license is active for one to five years, depending on the duration of the license you have purchased. During the site license duration, you are free to distribute your keyed link to all faculty, staff, and students of your school campus. In the case of your school having multiple campuses, a separate purchased license is required for each campus.

For details regarding Vernier Video Analysis site licenses, please refer to https://www.vernier.com/til/7059

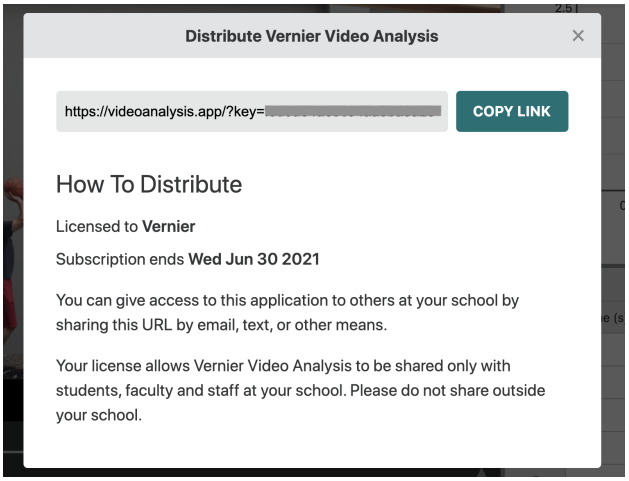
Distribute Vernier Video Analysis to Colleagues and Students

Go to videoanalysis.app; enter your license key, if necessary. You should immediately see the welcome screen as shown in Step 1.

To access your licensed software, your colleagues and students need a link tied to your license key. To access this link, click or tap Other Options, ···, then choose Distribute App.



A box will appear with your license key link and license expiration date. Click or tap **COPY LINK** to copy the link to your device's clipboard. Paste the link into an email or add it to a password-protected site such as your school's learning management system (LMS). The URL will open the fully-authenticated app without prompting for a license key.



Privacy Statement

COPPA, SOPIPA, and FERPA Compliance

Vernier Video Analysis complies with federal regulations pertaining to student privacy and safety in the following ways:

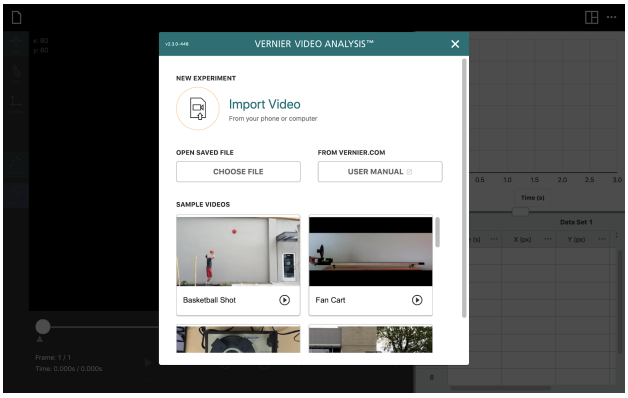
- Vernier Video Analysis does not collect, request, share, or store any personal information from students or instructors.
- Vernier Video Analysis does not display advertisements in the app.

II. Video Analysis Basic Steps

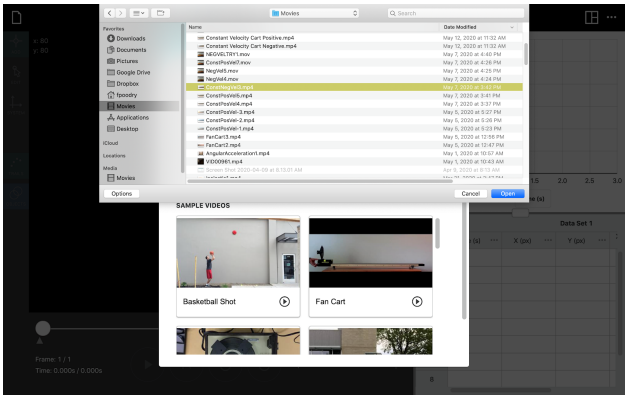
Follow these steps to quickly get started with analyzing a video. These steps assume you already have Vernier Video Analysis open in a browser window, at videoanalysis.app

Step 1: Import a video into Vernier Video Analysis

1. Click or tap Import Video or choose one of the sample videos. Scroll to see additional sample videos. Click or tap **CHOOSE FILE** to open saved Vernier Video Analysis files (.vmbl).

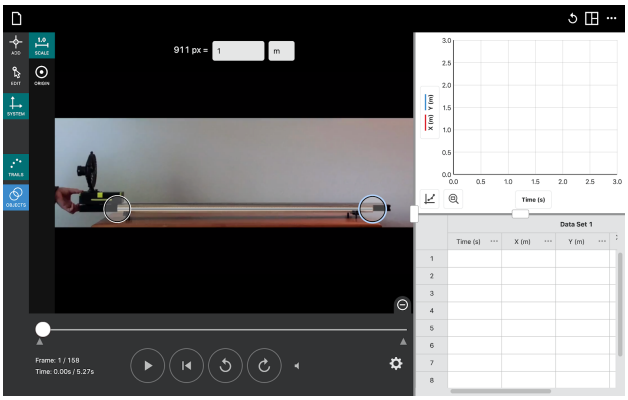


2. If you choose Import Video, select a video file and click or tap Open. The look of the selection dialog will depend on your device.

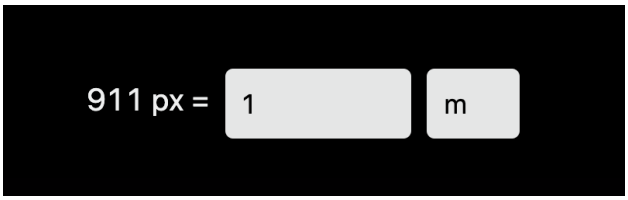


Step 2: Set the scale and the origin

1. Click or tap System, ↕→, and then Scale, 1.0. Move the centers of the scale circles to the ends of your scale object.

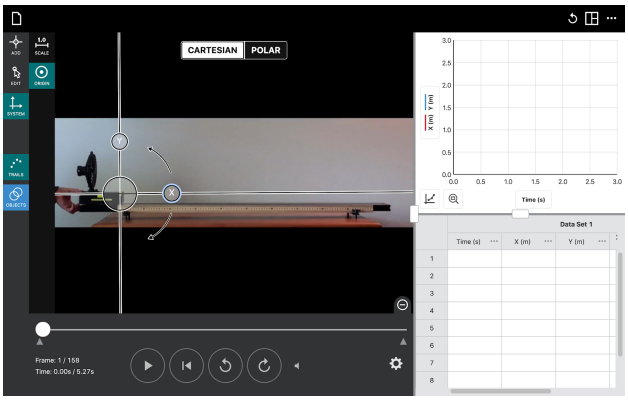


2. Type in the value and units of your scale object.



3. Click or tap Origin, ⊙. Move the origin to where you want it. The horizontal direction is X and the vertical direction is Y.

   Adjust the rotation of the axes, if desired. For example, you may want to orient the x-axis so that it aligns with a ramp. Click or tap the X or Y and drag to rotate the axes to align as desired.



Polar coordinates can be set initially or turned on after the data has been marked. For additional information, see the Analysis Tools section.

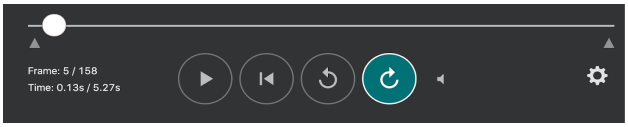
Step 3: Mark points

You can manually track an object's motion, or you can use the Autotracking feature. Continue with these steps to manually add points. To learn about Autotracking, skip to the Autotracking section.

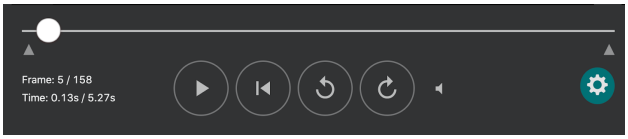
Manual Tracking

1. Click or tap Add, ⌖, to add points for motion analysis.

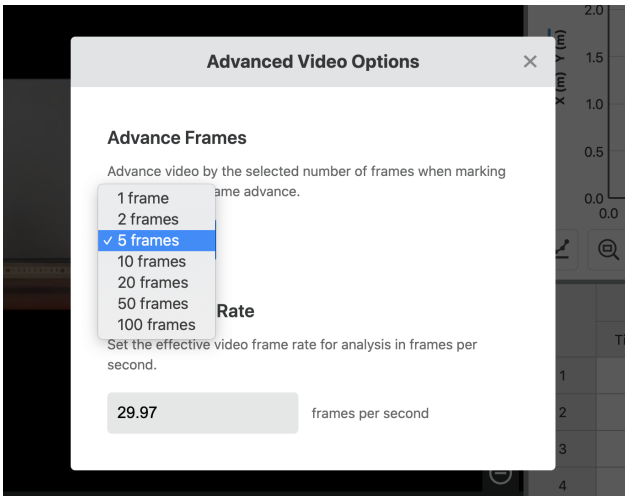
2. Use Step Forward, ↻, and Step Back, ↺, to advance the video to the desired frame. Typically, this is the frame when motion begins or right before motion begins.



If desired, you can trim the beginning and end of the video clip to include only the motion of interest. See the Additional Video Features section for details.

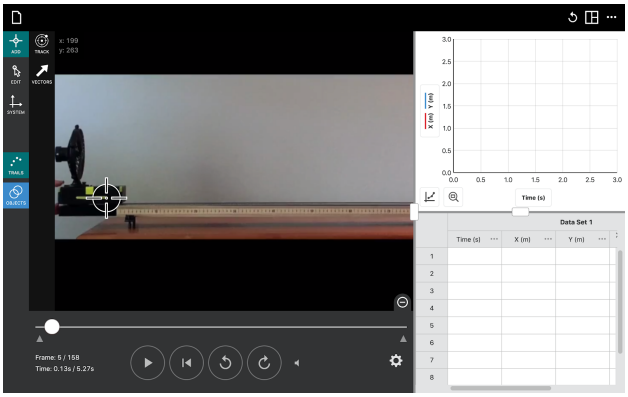


If you would like to change the frame increment for advancing through the video, click or tap Advanced Video Options, ⚙. You can change the increment at any time while you are marking data points.



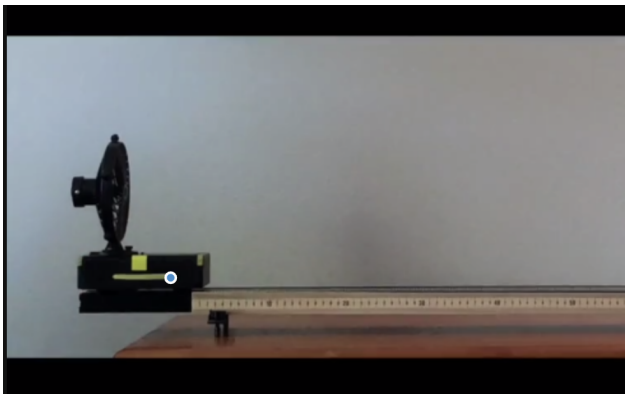
Note: Not all values shown here may be shown for your video, depending on how many frames your video contains.

3. Move the crosshairs to the point on the object that you want to track.

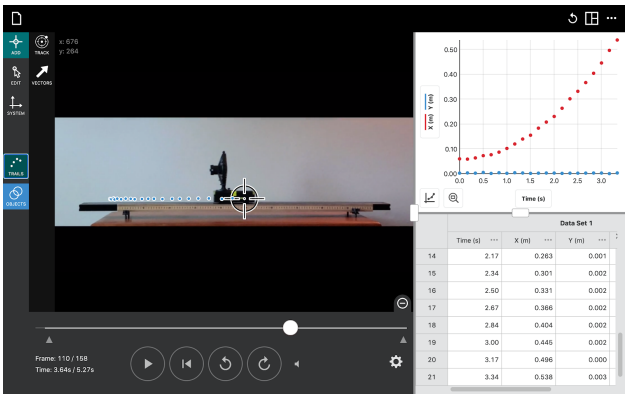


TIP! *Enlarge the video window for more precision in marking points. Use View, ⊞, to remove the graph and data table. To further enlarge the view, zoom in using the scroll wheel on a mouse or with pinch gestures on a trackpad or touchscreen device (e.g., a tablet). Then pan across the video by dragging with two fingers, or hold down the Shift key on your keyboard, then click and drag across the video.*

4. When you click or tap to mark a point, the coordinates of the point will be recorded in the data table, a point will be added to the graph, and the video will advance one frame (or however many frames you have selected).



5. Continue to click or tap on the moving object to mark points until you reach the end of a video or the end of the portion of the motion you are analyzing. **Note**: It is important to be consistent and always mark the object at the same location on the object.



TIP! *If the visible points are in the way of placing subsequent points accurately, click or tap Trails,* , *to show only the point in the current frame.*

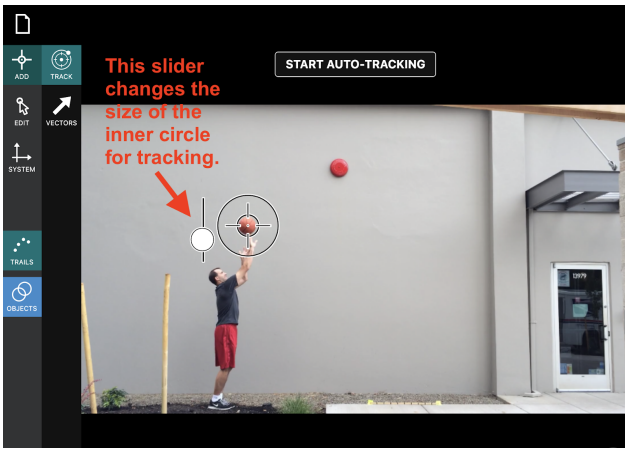
TIP! *You can advance the video without marking a point or change the number of frames to advance with each point, even if you have already started marking points.*

Autotracking

Vernier Video Analysis can automatically locate an object and mark its location with a point as it moves. This feature can speed analysis of longer videos and remove the tedium of marking many frames. If the software is unable to identify the object against the background, autotracking stops.

The characteristics of your video greatly affect the ability to use autotracking. In general, a plain background provides a better contrast. A blank white or gray wall is best, as even cinder block edges can cause the software to lose tracking. It is also helpful if the color of the object you are

tracking contrasts well with the background. For example, use a brightly colored ball or place a bright sticker on a dark object.



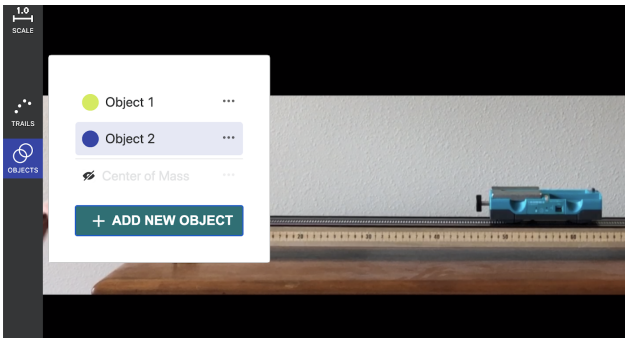
To use autotracking, click or tap Track, . Center the autotracking cursor on the object to be tracked and use the slider to adjust the size of the inner circle so it is slightly larger than the object. Click or tap **START AUTO-TRACKING** to begin. If the object is lost, tracking stops; to continue, reposition the cursor on the object and restart autotracking.

If autotracking is unreliable, try making the inner circle slightly smaller or larger. If your object is larger than the outer circle, autotracking may not be possible, but you can try tracking the leading or trailing edge of the object. For large objects, place a bright sticker on the object before recording video to improve autotracking.

You can assist autotracking through complex motions or backgrounds by using a mixture of autotracking and manual tracking. To mark points manually while in autotracking mode, drag the autotracking cursor to the location you want to mark, and then tap or click to leave a manual point.

Add Points For an Additional Object

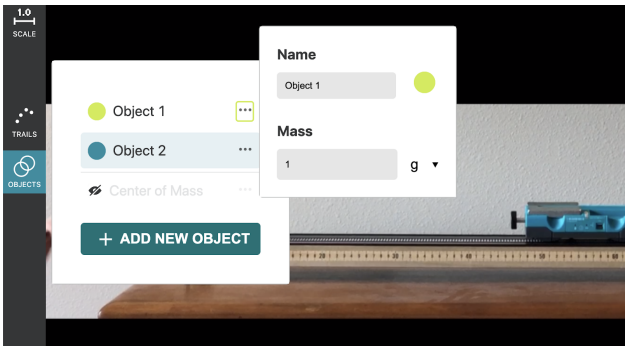
Tracking multiple objects is useful to study collisions and other interactions. When two or more objects have been tracked, the option to calculate the center of mass is available.



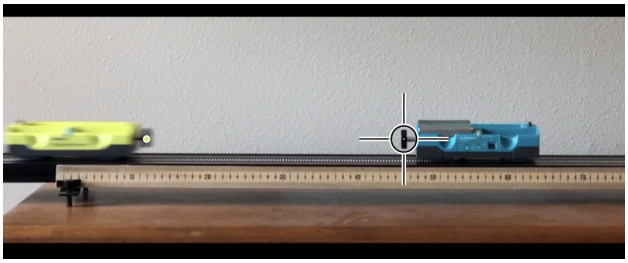
1. Click or tap Objects, , to add points for additional objects. When you click or tap **+ADD NEW OBJECT**, an additional object will be added with a different dot color. Change the dot color by clicking or tapping the dot and choosing a new color.

   TIP! *To switch between objects, click or tap Objects, , and then select a different object.*

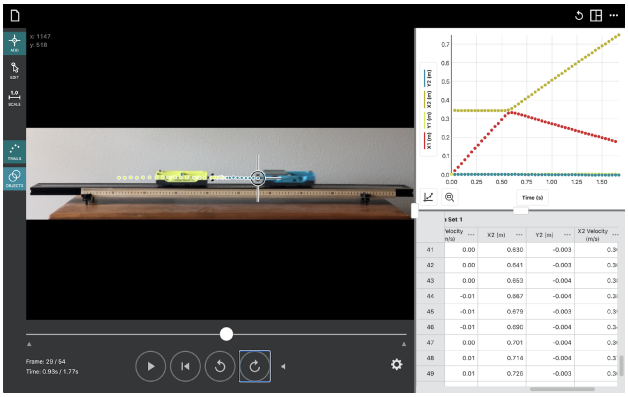
2. Click or tap Settings, ⋯, for each object to change the name and enter the mass of the object (optional).



3. Starting with the first video frame that contains a marked point, click or tap your second object to collect data for its motion.

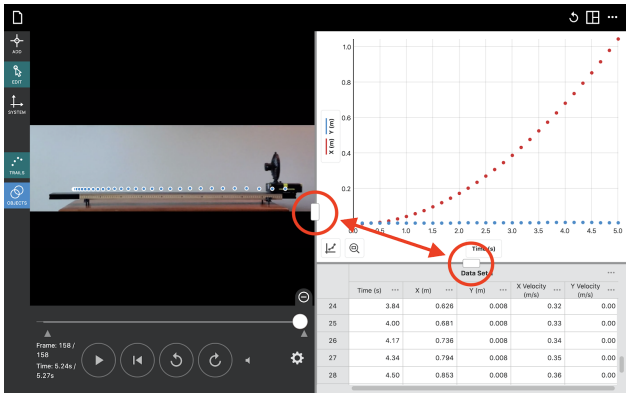


4. Continue marking the location of the second object in the same frames in which you marked the first object.



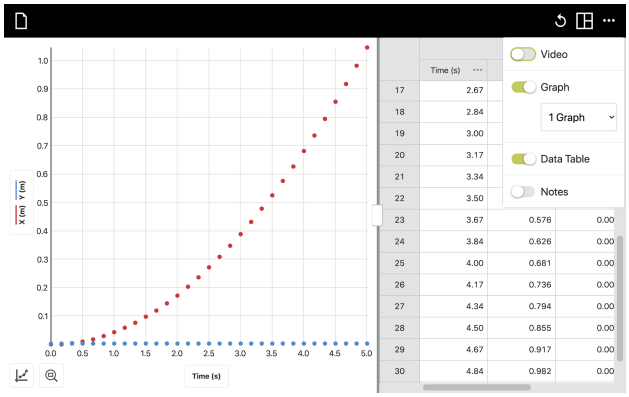
Step 4: Analyze the graph

1. If you want to make the graph larger, click-and-drag or tap-and-drag the handles to adjust the borders of the video, graph, and data table in the Video Analysis window.

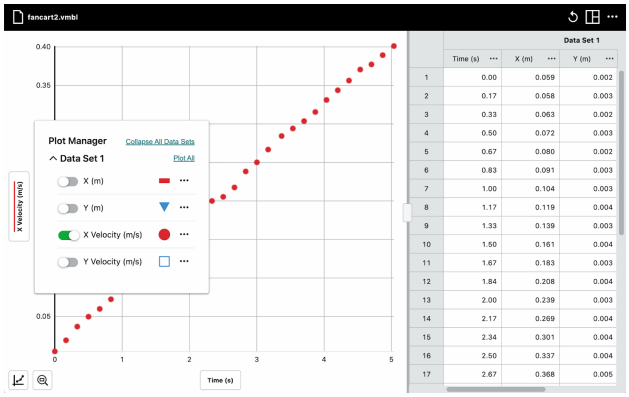


2. Change which elements are visible using View, ⊞.

   ***TIP**! The View menu also includes a Notes option, which allows you to document details regarding your experiment.*



3. To change which data are graphed, click or tap the vertical axis label to open the Plot Manager.

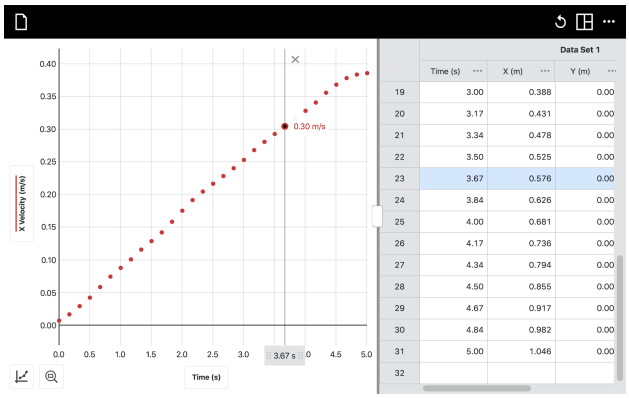


4. Click or tap the graph to examine a point of interest. The parameter and time values of the point are shown.

   Click or tap a different point or drag the Examine line to further examine your data. You can also click on the label of the Examine line and then use the arrow keys on your keyboard to move the line point by point.

   To remove the Examine line, click or tap Close, ×, displayed next to the line.

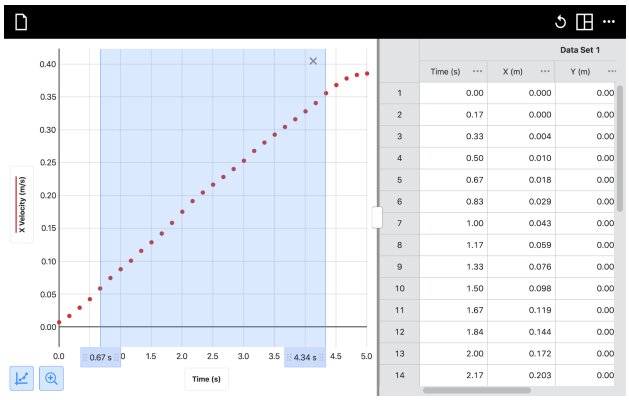
   When viewing multiple graphs, the Examine line shows on all graphs.



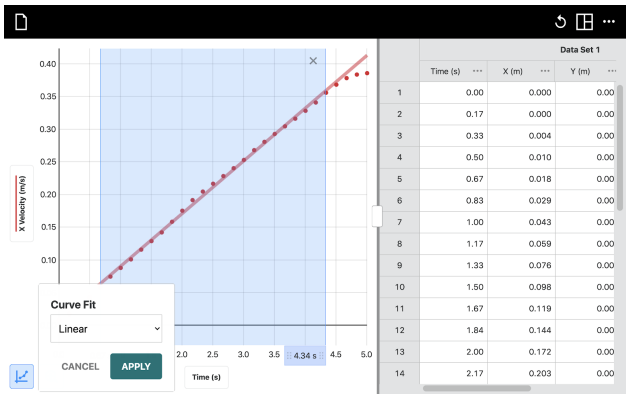
5. Click-and-drag or touch-and-drag across the graph to select a region of data for analysis. The selected region becomes highlighted.

   - To modify a region, drag the label at the edge of the selected region to the desired location.
   - To remove a selection, click or tap Close, ×, displayed on the region.

   TIP! *To analyze all data, you do not need to select a region.*



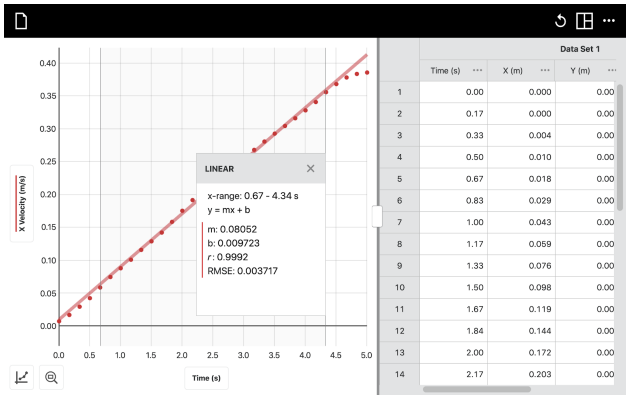
6. To fit a curve to the data, click or tap Graph Tools,  , and choose Apply Curve Fit. Then, select the desired fit type. A preview of the curve fit is displayed on the graph.



7. Click or tap **APPLY** to display the curve fit equation and coefficients on the graph.

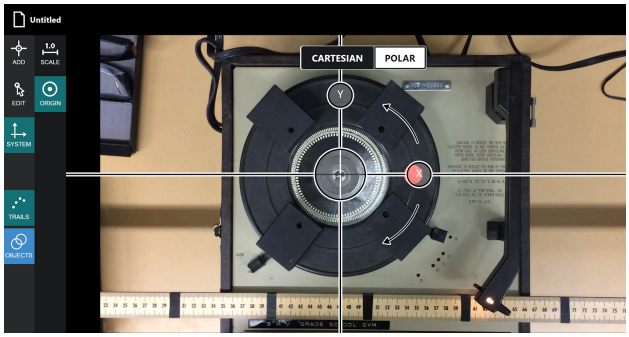
   To remove the curve fit, click or tap Close, ×, on the details box.

   TIP! *If the Curve Fit box covers part of your data, click or tap the gray area at the top of the box, then drag the box to another location on the graph to avoid obscuring data.*



Alternating Between Polar and Cartesian Coordinates

Click or tap System, ⊥→, then Origin, ⊙.



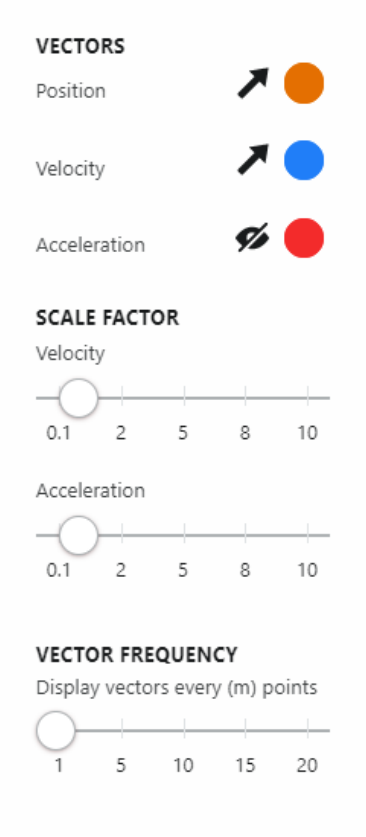
You will see the option for alternating between Cartesian and polar coordinate systems. Depending on the motion you are analyzing, you may want to adjust the position of the origin as well.

When you convert to a polar coordinate system, additional data columns will be available to graph, including radius (r), angle (θ) measured in radians, rVelocity, and θVelocity. When you move the origin, the values for all available parameters adjust to match the current coordinate system.

Adding Vectors to Your Video

You can include position, velocity, and acceleration vectors to your video once you have marked data points. Click or tap Add, , and then Vectors, . You can add vectors for Position, Velocity, and/or Acceleration. Click or tap the icon next to the color dot to cycle through the available vector options:

- resultant vector
- component vectors
- resultant and component vectors
- off (no vectors)



Click or tap the color dot to change the color of the vector.

Each position vector extends from the origin to the marked position of the object. Adjust the relative length of velocity and acceleration arrows using the Scale Factor sliders. You can also adjust the frequency that the vectors are shown. This is useful for decluttering your video image.

For more information, see the Vector Display section in Part V.

If you have more than one object marked for position data, you will only see the vectors for the object selected. To change the object selected, click or tap Objects, , and select the object of choice.

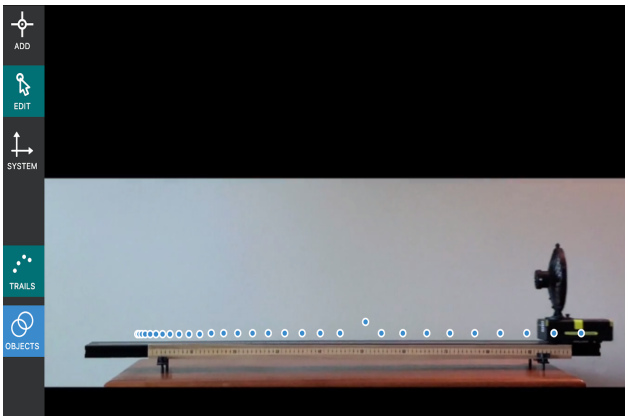
Step 5: Edit your work

If you want to move or delete a marked point, first click or tap Edit, .

TIP! *Vernier Video Analysis does not save changes automatically. If you want your changes to be saved, click or tap File, , and choose Save or Save As.*

Move Points

Once you're in editing mode, you can select and drag any point. It is easier to reposition a marked point if you turn off Trails, , and use Step Forward, , and Step Back, , to the video frame that corresponds to the point you want to edit.

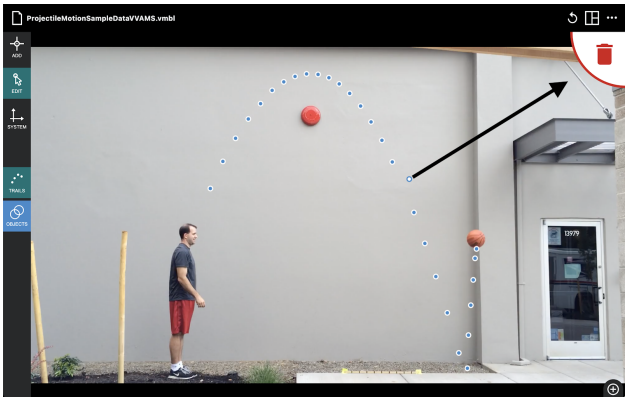


Delete Points

There are two ways to delete a point. In both cases, first select the point you want to delete. When selected, the color of the point will change to white.

Method 1 is to drag the point up to the upper right where a trash can, , will appear. Continue dragging the point into this area and then release the point to delete it.

Method 2 can be used if you are using a device with an external keyboard. For this method select the point and press the Delete button on your keyboard.

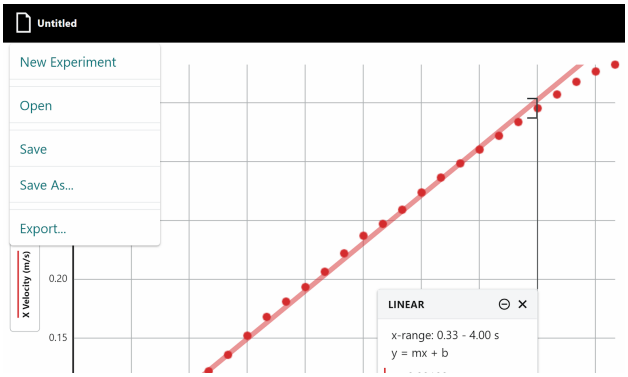


Adjust Scale or Origin

To update scale or origin location, click or tap Scale, . Reposition the scale and/or origin as needed.

Step 6: Save your work

Click or tap File, , to find the Save and Save As… options.



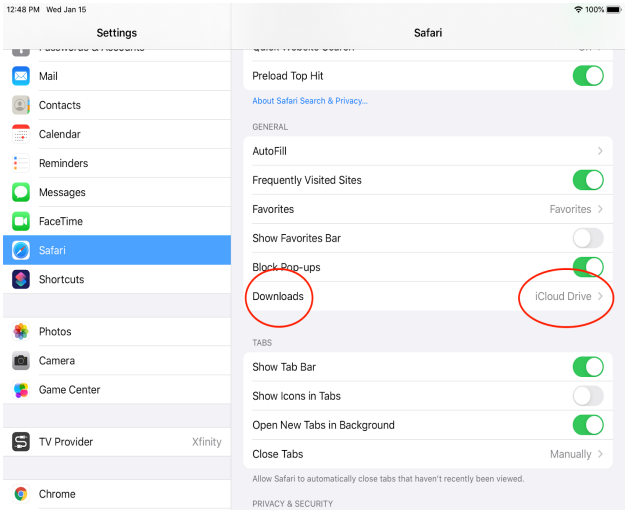
Most browsers will prompt for a file name and location. Depending on the settings in your browser, you may not be prompted to the saved location and file name; if this is the case, look in the downloads folder you have configured for your browser.[1]

Saved files include the inserted video.

When using Safari on iOS and iPadOS devices: Choosing Save As… saves the file to your device's Downloads folder.

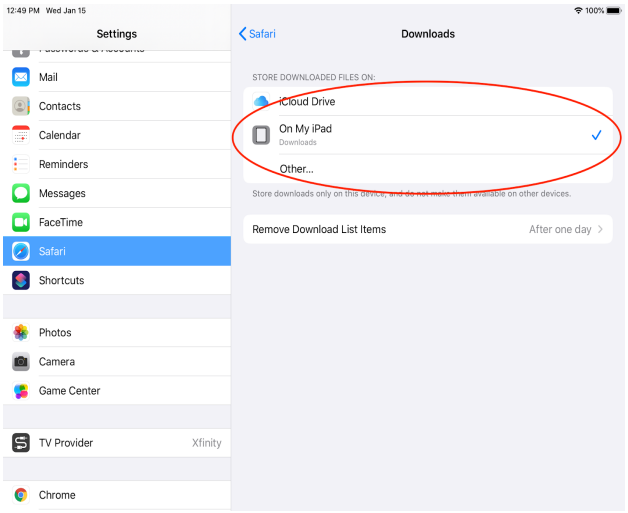
This folder is either on iCloud® or on your device, depending on your device settings.

You can change the location in Settings by choosing Safari and changing the Downloads location setting.



[1] To change this setting in Chrome, go to Settings>Advanced>Downloads and enable "Ask where to save each file before downloading." You will need to restart Chrome for the change to take effect.

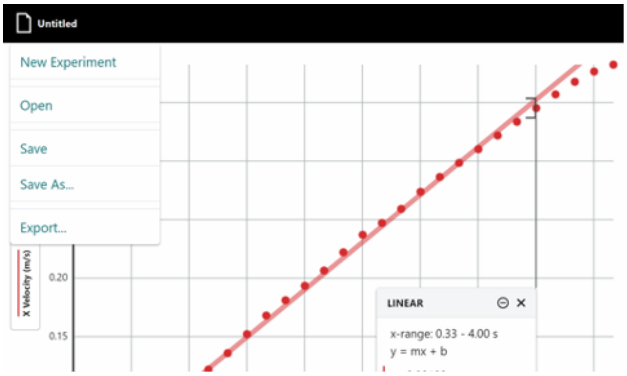
Once the file is saved to your Downloads folder, you can move it to any location, including Google Drive™ or other cloud locations that are available on your device.



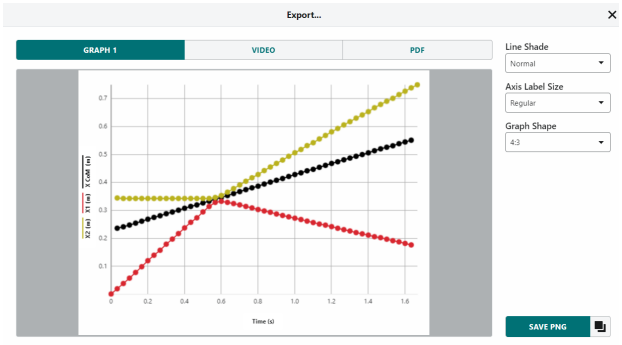
Step 7: Share your work

Export

Click or tap File, 🗋, to access the Export… option.



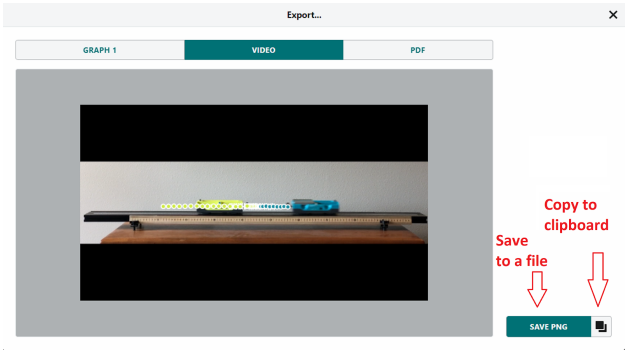
You can export a graph image, a still video frame, or an experiment report as a .pdf file. The export of a graph or video frame can either be saved as a .png image file, or it can be saved to the clipboard to be pasted directly into a lab report.



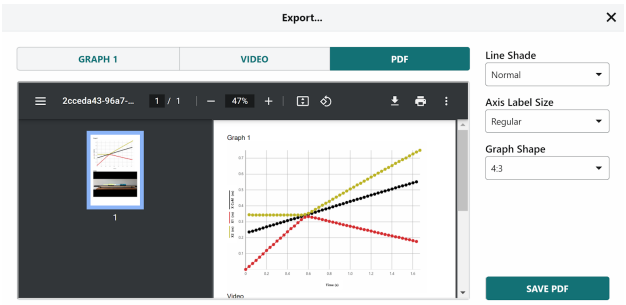
For a graph, you can adjust the saturation of the lines on the graph, the relative size of the axis labels, and the aspect ratio.

If you want to export a video frame, prepare by setting the video to the frame you would like to share, and add the scale, trails, or vectors as you desire.

The exported image will show whichever frame of the video is on the screen when the Export… window is opened.



When you choose to export the experiment details as a pdf, the file will include an image of the graph, the visible video frame, and any notes you have added to your file.



Print

You cannot print directly from Video Analysis. To print a Video Analysis file, use Export to create the desired file. Print the resulting file using the print options available on your device.

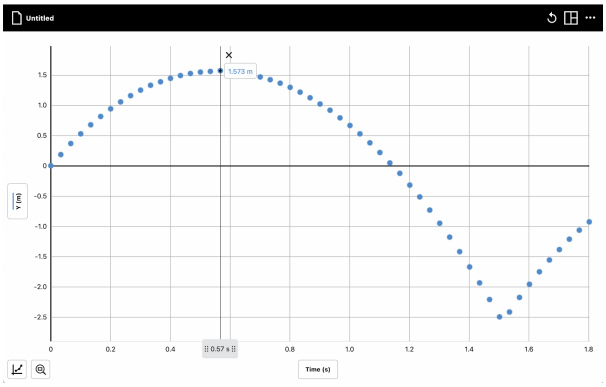
III. Analysis Tools

Examine Data Points

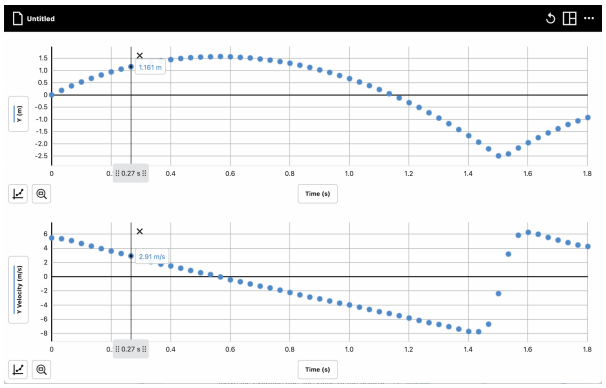
Click or tap the graph to examine a point of interest. The coordinates of the point are shown.

Click or tap a different point or drag the Examine line to further examine your data.

To remove the Examine line, click or tap Close, ×, displayed next to the line.



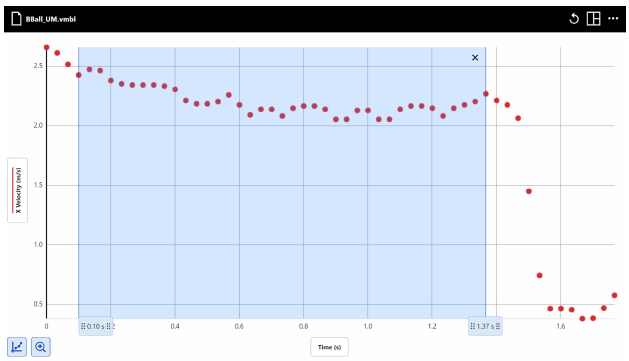
When viewing multiple graphs, the Examine line displays on all graphs referencing the same independent variable.



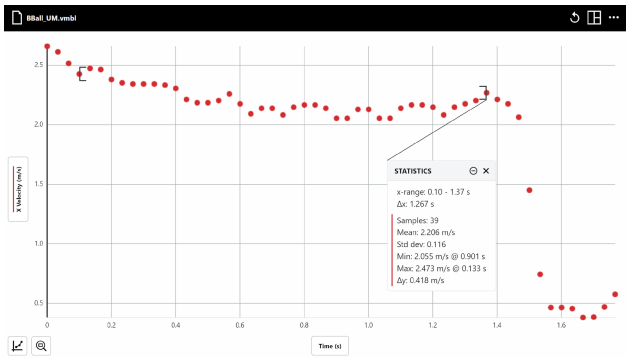
Statistics

Use the Statistics tool to calculate statistical attributes based on your data. Displayed values include number of points, mean, standard deviation, minimum, maximum, and range. Statistics for all plotted columns are calculated.

If desired, select a region of data. If a region of data is not selected, the Statistics tool uses all the displayed data in the calculation.



Click or tap Graph Tools, , and choose View Statistics. Statistics for all plotted columns on the graph are calculated and displayed in the Statistics details box.

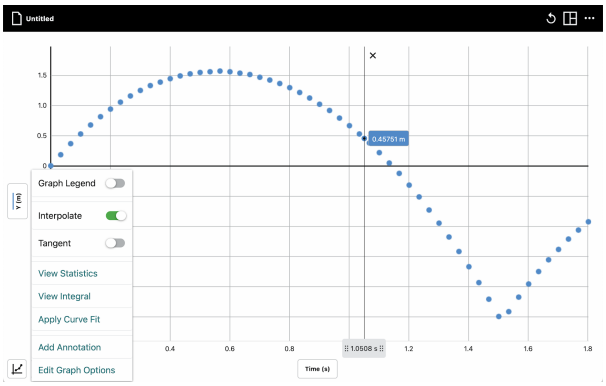


To dismiss the Statistics box, click or tap Close, ×. To minimize the Statistics box, click or tap Minimize, ⊖.

TIP! *If the Statistics box covers part of your data, click or tap the gray area at the top of the box, then drag the box to another location on the graph.*

Interpolate and Extrapolate Data

To examine values between and beyond your data points, click or tap Graph Tools, , and choose Interpolate.



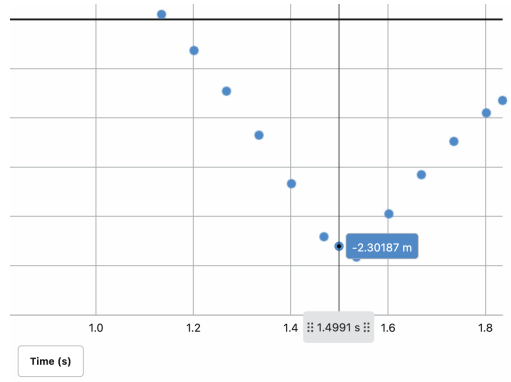
The interpolate function affects the behavior of the Examine line when examining data.

While interpolate is off, the displayed examine values are for plotted data points. As you move the examine line, the value of the nearest data point is displayed.

While Interpolate is on, you can estimate values between plotted data points. The values displayed depend on whether or not you have a curve fit plotted on the graph.

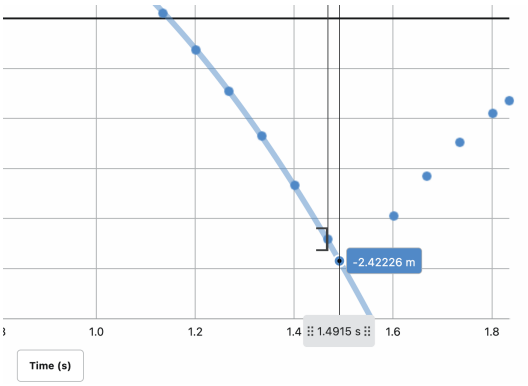
Interpolate Without a Curve Fit

When there is no curve fit, the Examine line follows the straight-line path between two consecutive points.



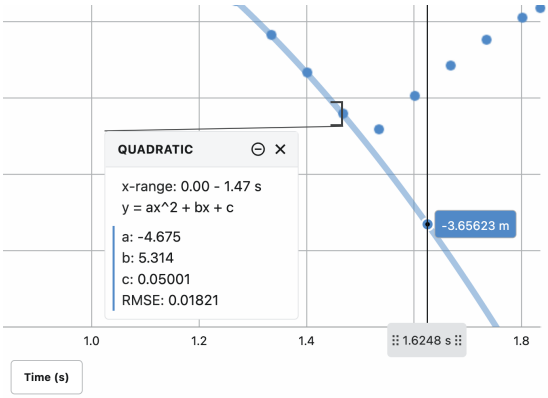
Interpolate With a Curve Fit

When there is a curve fit, examine follows the curve fit model to determine the examine values.



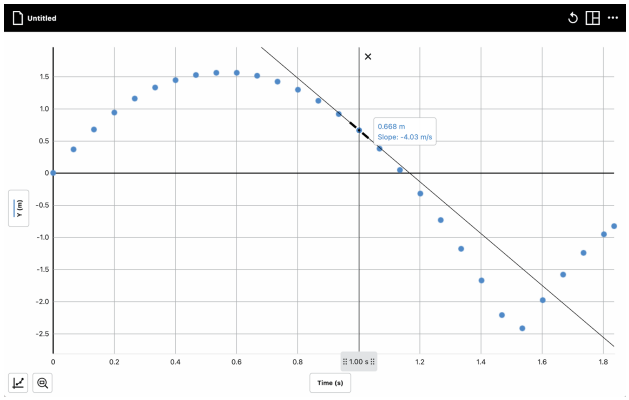
Extrapolate With a Curve Fit

To examine data points beyond your data (extrapolate), you must have a curve fit plotted on the graph and interpolate turned on.



Explore Rate of Change (Tangent)

To find the rate of change of your data at any point, click or tap Graph Tools, , and choose Tangent.

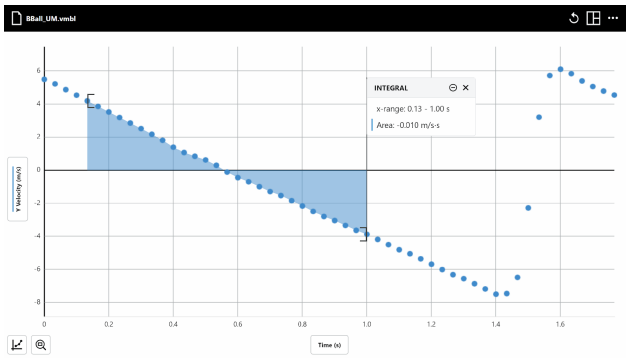


The Tangent tool calculates the rate of change of the data (slope) at the examined point. The tangent value is determined based on the points immediately around the examined point.

TIP! *You cannot use Interpolate and Tangent at the same time. Activating one tool de-activates the other.*

Integral

Use the View Integral tool to calculate the numerical integral (area) associated with your data.



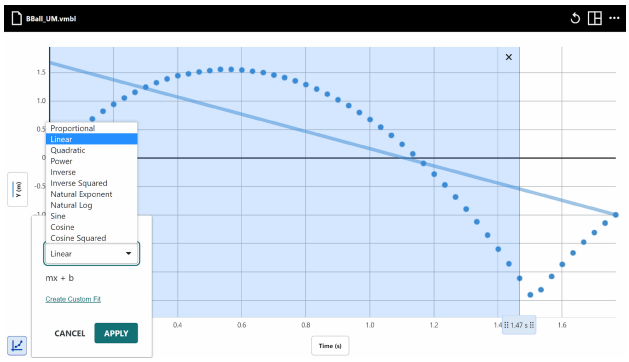
The Integral tool automatically uses the entire data set, unless a region is selected. When a region of the graph is selected, the integral is calculated for only the selected range. Click or tap Graph Tools, , and choose View Integral to find the integral.

The associated area is shaded and the value is displayed. Regions above the horizontal axis (x-axis) are positive, while regions below the axis are negative. Areas for all plotted columns are calculated and displayed in the Integral details box.

Curve Fit

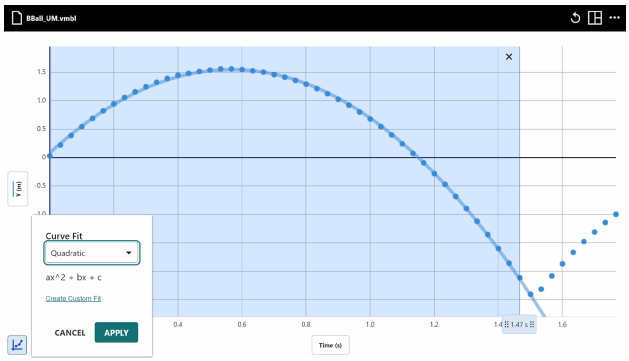
Use the Curve Fit tool to find a mathematical model that fits your data. Select a region first to fit a section of your data. When you select the tool without first selecting a region, all the data are used to determine the fit model.

Click or tap Graph Tools, , and choose Apply Curve Fit. The default fit is Linear. Scroll through the pop-up menu as needed to find additional fit options.

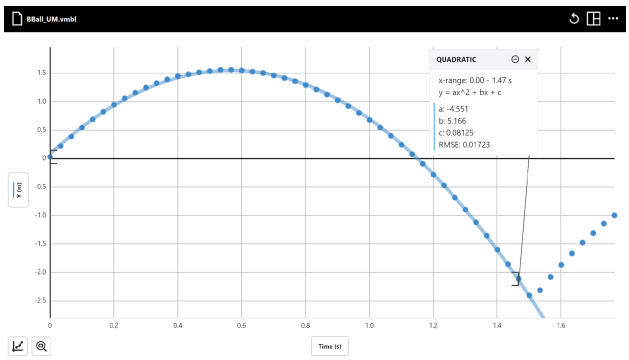


Curve fit models include Proportional, Linear, Quadratic, Power, Inverse, Inverse Squared, Natural Exponent, Natural Log, Sine, Cosine, and Cosine Squared.

Select a curve fit model to preview the fit to your data. Then, click or tap **APPLY** to display the curve fit equation and coefficients. Curve fits for all plotted columns are calculated and displayed



The curve fit details box includes the RMSE (root mean square error), a measure of how well the fit matches the data. Linear curve fits also show the correlation coefficient (*r*) associated with the linear fit.

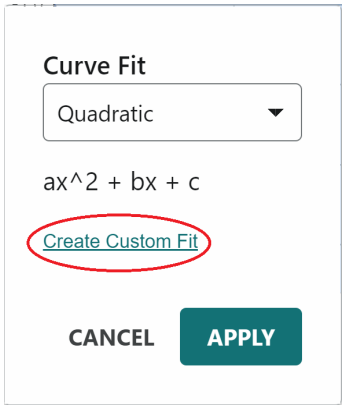


Customized Curve Fit

You can create a custom curve fit expression by modifying an existing expression or entering a new expression. The independent variable, x, is used to represent the data column plotted on the horizontal axis. Parameter labels can be one or more letters (except x) and are case sensitive.

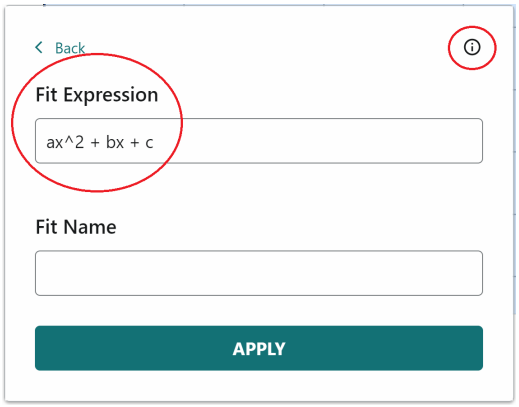
1. If desired, select a region of data, then click or tap Graph Tools, , and choose Apply Curve Fit. Then click or tap Create Custom Fit.

   TIP! *You can first select a curve fit model with an expression that is most similar to the one you want to enter. When you select Create Custom Fit, the equation will be available for you to edit, making it easier to create your own expression.*



2. Enter a custom fit expression. Modify the expression as needed.

   TIP! *You can click or tap Info, ⓘ, for in-app access to the details related to entering an expression.*



Supported Operators

+ – * / ^ ( )

Supported Functions

exp( ), ln( ), log( ), sqrt( ), sin( ), cos( ), tan( )

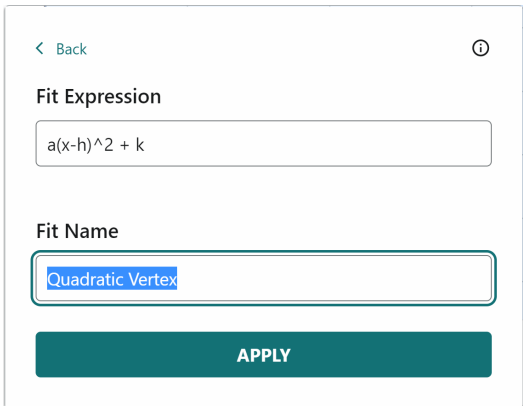
Example Expressions

Modified Linear	A + B*x ***or*** slope*x + intercept
Modified Quadratic	A(x – h)^2 + k ***or*** A(x–a)(x–b)
Base-10 Exponent	A*10^(Bx + C) + D
Gaussian	A*exp(– (x–B)^2/C^2) + D

Expression Details

- An expression must include the independent variable and at least one parameter.
- Functions and the independent variable must be lower case. [sin(x) not SIN(x) or sin(X)]
- There can be no more than six parameters in an expression.
- Multiplication can be explicit or implied. [A*x or Ax]
- Parameters cannot be repeated within an expression. [A(x + y) not Ax + Ay]
- Trigonometric functions are evaluated in radians except when the column plotted on the horizontal axis has units of deg, °, or degrees.

3. Add a name for your fit, if desired. If you do not add a name, the expression itself is used as the fit name.

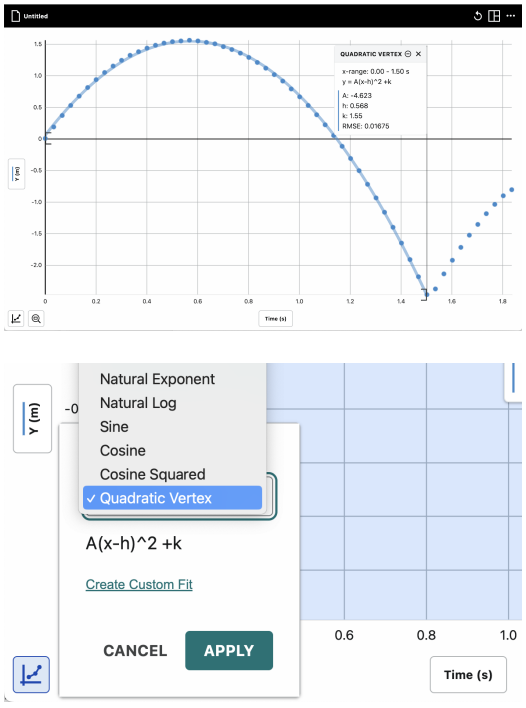


4. Click or tap **APPLY** to apply the custom fit expression to your data.

   Once you have applied a custom fit to your data, you can apply that fit to other data in the same file.

   Custom curve fit expressions are saved along with the data and other experiment settings when you save the Video Analysis (.vmbl) file.

   Note: Custom curve fits are only available in the file in which they are created. Starting a new experiment, opening a different file, or restarting the app will remove the custom curve fit from Video Analysis.

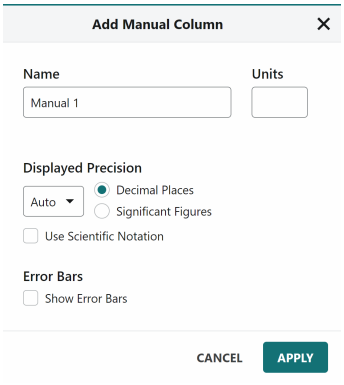


Add Additional Columns

Add a Manual Column

Add manual columns to bring in data from other files or data found on the internet to compare with your data. Or, you can use manual columns to add data relevant to your experiment. For example, if you have a video displaying the stretch of a spring as different masses are suspended from it, you can create a manual column of data to include the mass in the data set.

From the data table or y-axis Plot Manager[2], click or tap Column Options, ⋯, next to an existing column name. Choose Add Manual Column to create a new manual entry column.

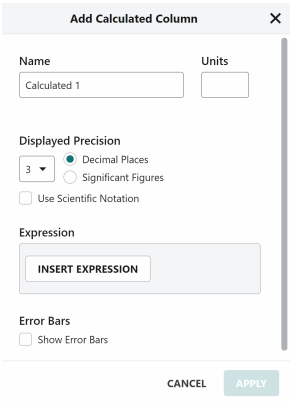


You can modify the column name, add units, and adjust the display precision of the new column as desired. After clicking or tapping **APPLY**, you can type data into the new column or copy and paste data from another file.

Add a Calculated Column

Calculated columns are columns with values that are based on other columns through a mathematical formula. For example, you can create a velocity magnitude column by calculating the square root of the sum of the squares of the x- and y-values of velocity. Or you can create columns of potential and kinetic energy from the values in the position and velocity columns.

From the data table or y-axis Plot Manager[2], click or tap Column Options, ⋯, next to an existing column name. Choose Add Calculated Column to create a new calculated column.



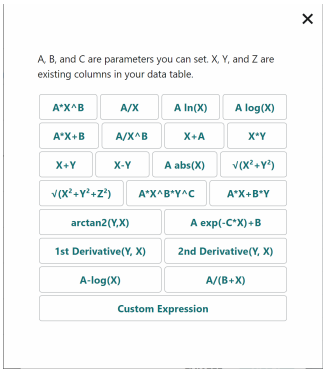
You can modify the column name, add units, and adjust the display precision of the new column as desired.

[2] To open the Plot Manager, click or tap the y-axis label.

Click or tap **INSERT EXPRESSION** to view your expression options.

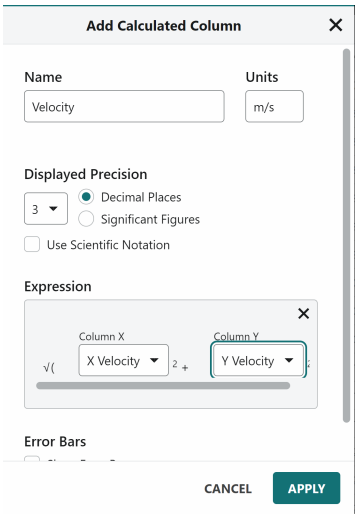
Select the desired expression to use for your calculated column.

TIP! *A and B represent constants. X, Y, and Z represent data columns from your data table.*



The column from which you accessed the column tools is used in the calculated column expression by default. Adjust the columns and parameters as desired.

TIP! *The new calculated column appears to the right of the column used to create the calculated column.*



Available Expressions

The calculated column expressions available in Vernier Video Analysis are displayed in the graphic above and include many useful expressions. Vernier Video Analysis also includes the following expressions:

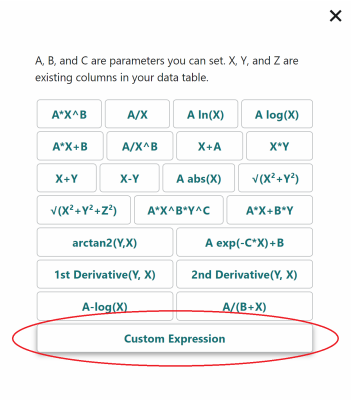
- $X+Y$, which adds two columns together. For example, if you have calculated columns for kinetic energy and gravitational potential energy, adding these columns gives the total mechanical energy.
- $\sqrt{\left(X^2+Y^2\right)}$, which gives the magnitude of a two-dimensional vector, or in the case of circular motion, gives the radius when the origin of the axes is placed at the axis of rotation.
- *arctan2(Y,X)*, which gives the angle in the *xy* plane relative to the positive *x* axis. Its value is in radians.

The latter two expressions are useful for analysis of rotational dynamics.

Custom-Expression Calculated Columns

You can use specialized functions to define custom expressions when creating calculated columns. This functionality extends your options when defining the calculated column expression.

1. When you open the Calculated Column dialog to view your expression options, click or tap **CUSTOM EXPRESSION** to create a custom expression.

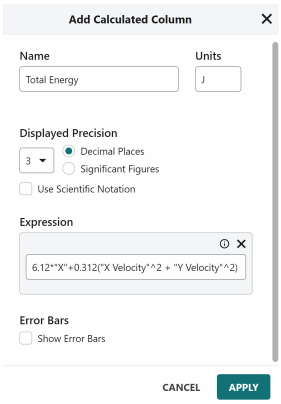


2. Enter the expression as desired.

   Note: The expression is checked for errors as it is entered. You must fix any errors before applying the expression.

   Click or tap Info, ⓘ , to access the library of functions and syntax.

   TIP! *When you begin typing a list of matching functions and variables appear. Click or tap the item to import it into your expression.*



3. Click or tap **APPLY** to create the calculated column.

TIP! *To edit a calculated column once it has been created, click or tap Column Options,* ••• *, next to the column name in the data table or y-axis Plot Manager and choose Column Options.*

Calculated Column Custom Expression Details

- An expression must be a number, a data column, an appropriately formatted function, or a combination of these items. [5, “X”, sin(“X”), or 5sin(“X”)]
- Supported operators are as follows: +, –, *, /, ^, (, and)
- Functions must contain their arguments in parentheses. [abs(“X”) or sqrt(2)]

- Multiplication can be explicit and implied. [5*“X” or 5“X” or 5(“X”)]
- Constants must be entered as numbers. Variable parameters (e.g., A, B, C) are not supported.
- Trigonometric functions are evaluated in radians.
- Functions can be nested as long as the proper format is used. [sqrt(abs(“X”))]

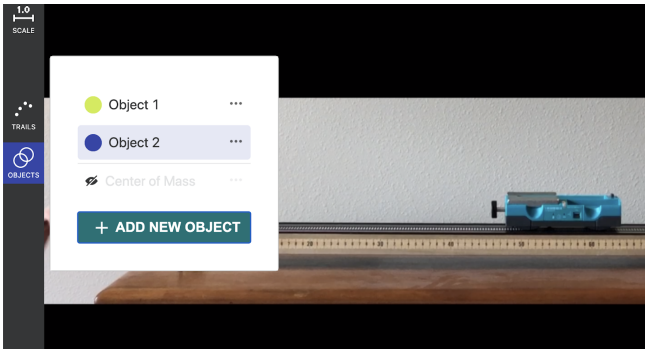
For a complete list of functions and their syntax, see https://www.vernier.com/til/11314

Center of Mass

When two or more objects have been tracked, Vernier Video Analysis can calculate the center of mass with user input for masses. This may be useful in investigating collisions in one or two dimensions.

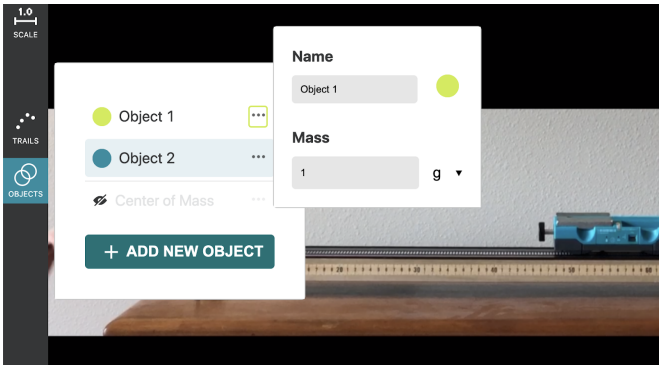
To use the Center of Mass function, click or tap Objects, .

When you click or tap **ADD NEW OBJECT**, an additional object will be added with a different assigned dot color. To change the dot color, click or tap the colored dot and choose a new color.



You can return to any point series for marking by selecting it from the list.

To change the name and the mass of the object, click or tap Settings, , for the object.

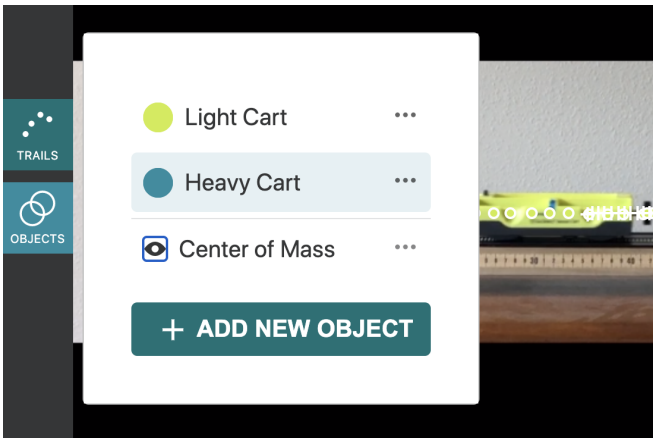


TIP! *Click or tap the triangle next to the mass unit to change the units used.*

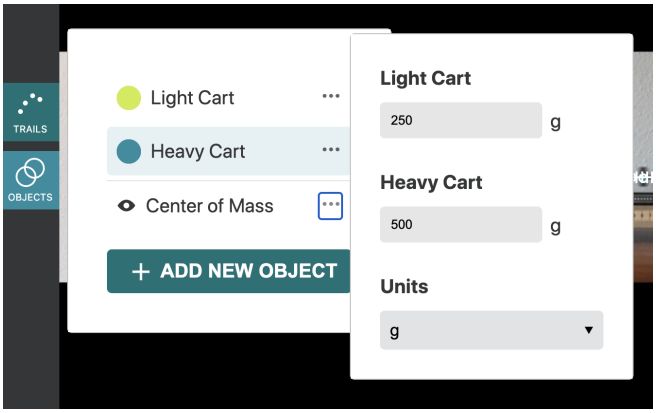
To show/hide the Center of Mass indicator, +, click or tap the icon next to Center of Mass.

- Center of mass displayed
- Center of mass hidden

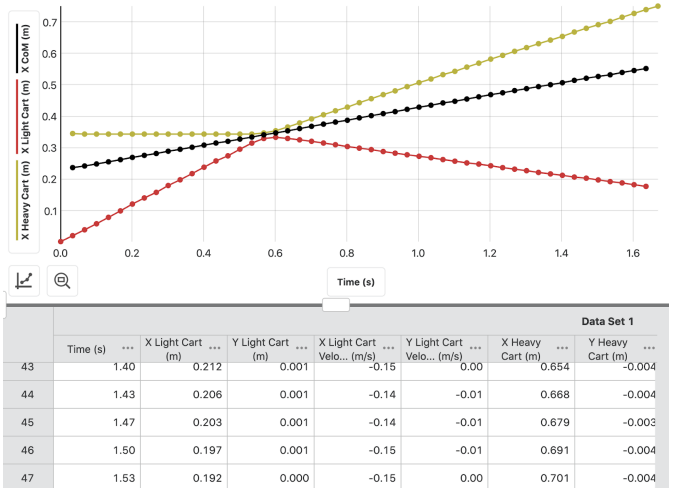
The center of mass will be indicated on each video frame with a + symbol.



To revise the masses of the objects, as well as the units for mass, click or tap Center of Mass Options, ⋯.



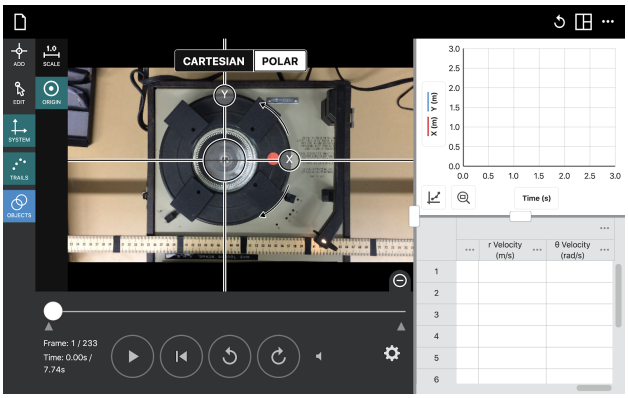
Changing the names of the objects changes the column names and the graph display names. Columns of both X and Y center of mass data are created in the data table and may be displayed on the graph.



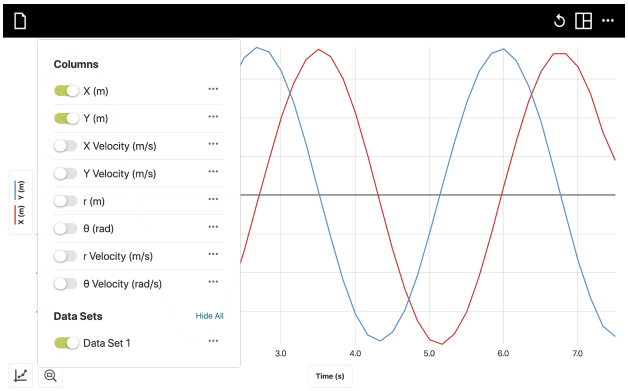
Use Polar Coordinates

Polar coordinates are useful when examining rotational kinematics.

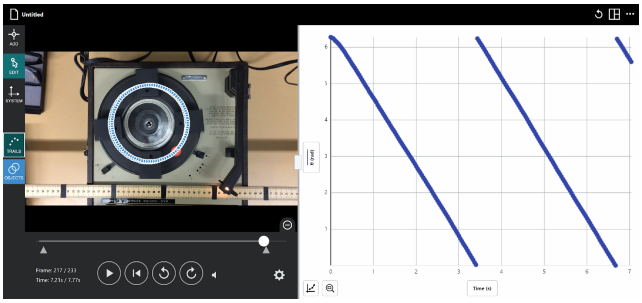
To use polar coordinates, click or tap System, ⟂, then Origin, ⊙. Click or tap **POLAR**.



When polar coordinates are selected, in addition to the X and Y positions and velocities, Vernier Video Analysis creates calculated columns for radius (r), angular position (θ), radial velocity, and angular velocity. Angles are reported in units of radians.



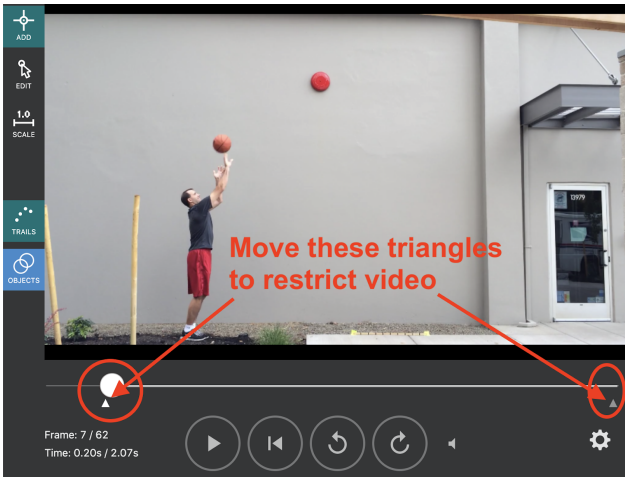
Angular position is calculated using the *arctan2* function. The angular position resets to 0 upon reaching 2π radians. The image to the right shows just over two full rotations of the turntable.



IV. Additional Video Features

Trim Video

If there are multiple frames of video before and/or after the motion to be analyzed in Video Analysis, the video playback can be restricted to only the frames containing the motion to be analyzed. Move the Range Indicators, ▲, at either end of the video scrubbing bar until only the relevant portion of the video plays.



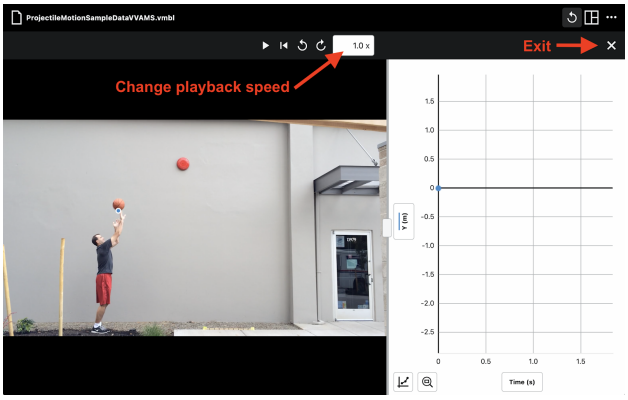
This is especially useful if you are tracking multiple objects and need to return to the same starting frame each time.

Replay

The Replay feature, located in the upper-right corner of the app, is for use after all the data points have been added. When you click or tap Replay, ↺, video playback is synchronized with all three elements: data table, graph, and video with added points. You can pause the video, or step through the video point by point using Step Forward, ↻, and Step Back, ↺.

Adjust the playback speed using the menu at the top of the playback view.

TIP! *Slow down the replay by entering a fractional value, such as 0.25 or 0.667.*

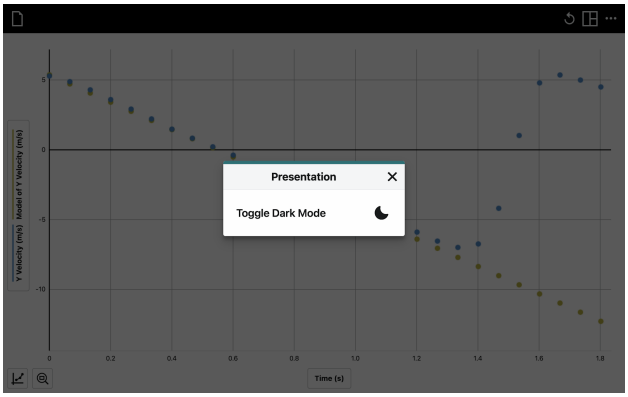


Exit the playback view using Close, ✕, in the upper-right corner.

V. Appearance

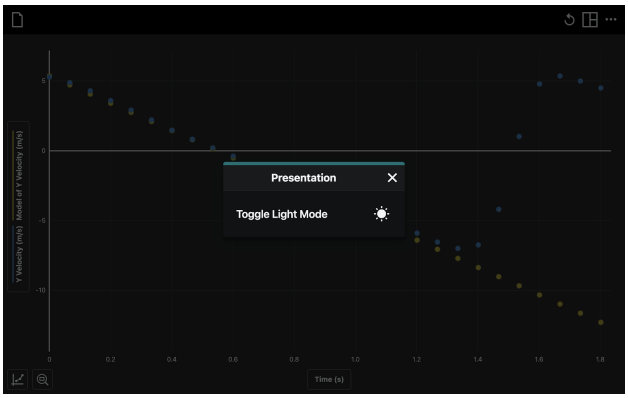
Modify the Presentation Settings

Click or tap Other Options, ⋯, in the upper-right corner of the app and choose Presentation to modify the presentation options. In the Presentation box, you can toggle between light and dark mode.



Click or tap Toggle Dark Mode, , to change the display to dark mode.

Click or tap Toggle Light Mode, , to change the display back to Light Mode.



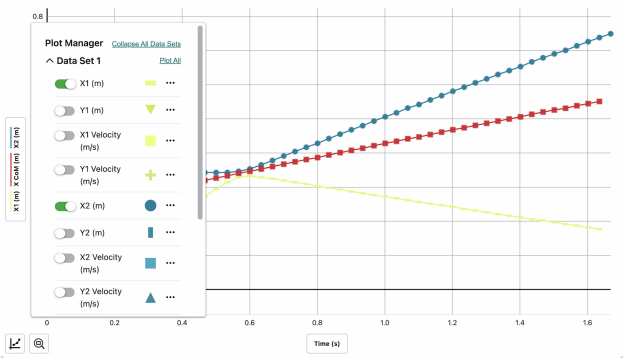
Managing Data

Change What is Plotted On the Graph

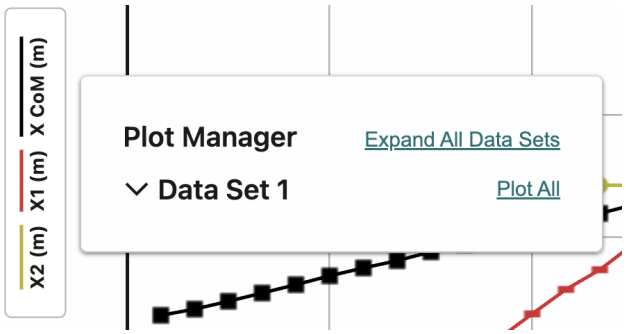
Click or tap the y-axis label to open the Plot Manager and change the data that are plotted on the graph.

Click or tap a column name to add or remove the column data from the graph.

TIP! *Column data for all selected columns are shown on the graph.*



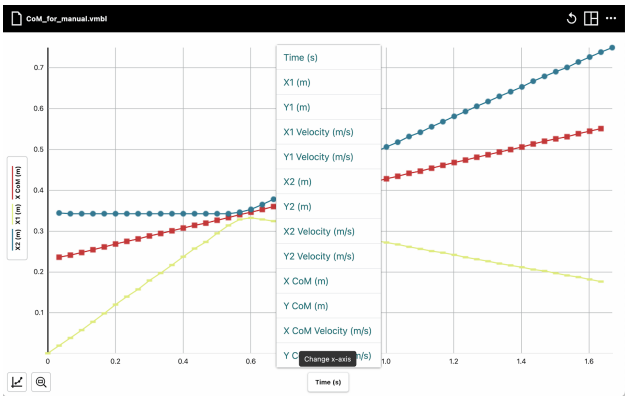
Click or tap a data set name, such as Data Set 1 (shown at right), to expand or collapse the list of columns in that data set. You can then easily plot or remove individual columns on the graph for that data set.



Click or tap Plot All (or Hide All) for a data set to quickly add or remove all columns of data plotted on the graph for the data set.

TIP! *Use Expand All Data Sets and Collapse All Data Sets to quickly show or hide all the columns in all the data sets in the Plot Manager.*

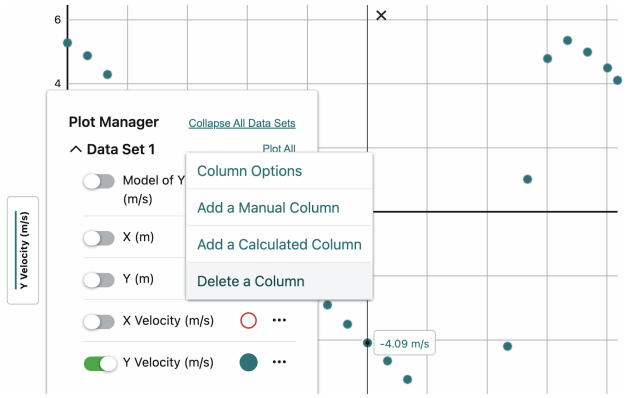
Click or tap the x-axis label, Time (s), to select the desired independent variable for your graph. Only one column can be used as the independent variable for any graph.



TIP! *You cannot plot a column* vs. *itself. If the column you select for the independent variable is already plotted on the vertical axis (y-axis), that column is removed from the graph.*

Delete Columns

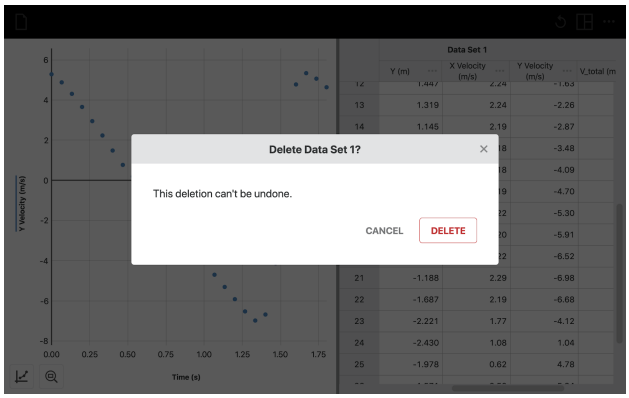
Position and time columns cannot be deleted. From the data table or Plot Manager, click or tap Column Options, ..., for an existing column. Choose Delete Column to remove manual or calculated columns.



Deleting a column cannot be undone. Click or tap **DELETE** to confirm the deletion.

Delete a Data Set

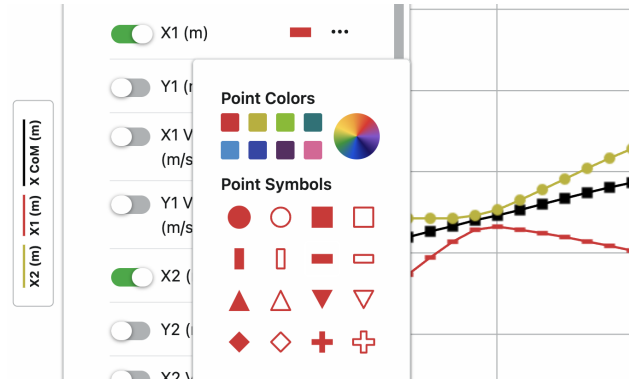
In the data table, click or tap Data Set Options, ⋯, next to the existing data set. Choose Delete Data Set. Deleting a data set cannot be undone. Click or tap **DELETE** to confirm the deletion.



TIP! *This is a convenient way to delete all data points and start over with analysis, if necessary.*

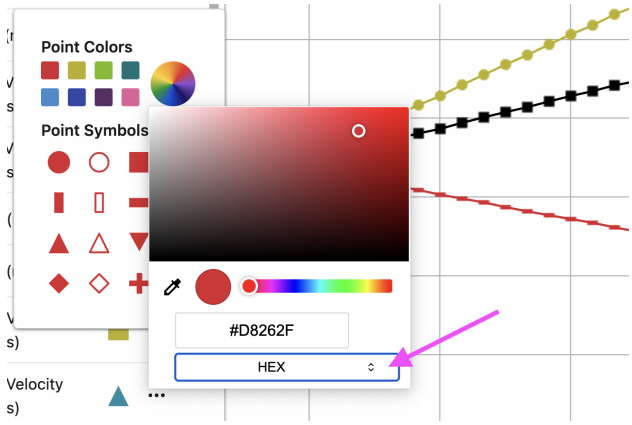
Change Point Symbol and Trace Color

Click or tap the y-axis label to open the Plot Manager. Then, click or tap the point symbol of any column and choose a different symbol or trace color.



TIP! *Changes to Point Colors and Point Symbols apply only to the column that was selected. The change is applied to any graph that is plotting the data in that column.*

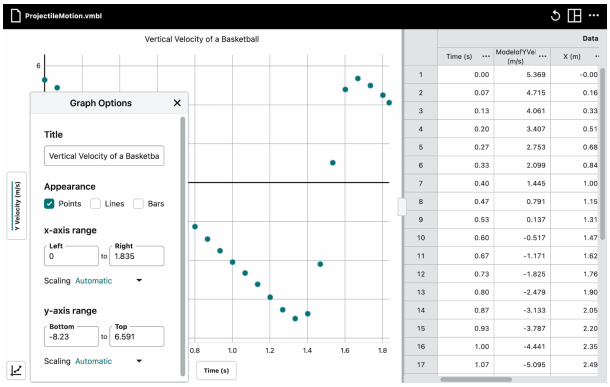
In addition to selecting a preset color, click or tap the Color Wheel, , for more color options.



TIP! *Custom colors can be defined using RGB, HSL, or Hex values. Click or tap the label under the color value(s) to change the input option.*

Change the Graph Appearance

Click or tap Graph Tools, , and choose Edit Graph Options to access Graph Options. In the Appearance section, you can change the style of the graph.

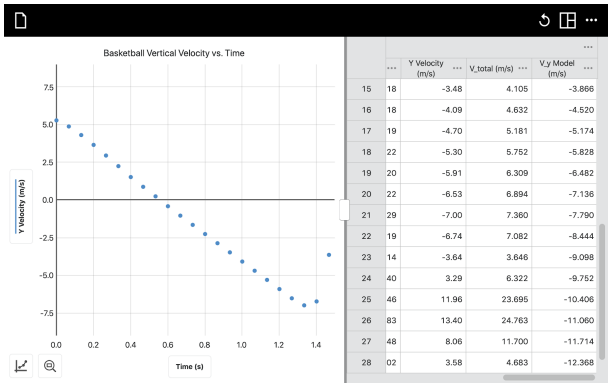


TIP! *When displaying multiple graphs, changes to the Graph Options only apply to the graph from which the tool is accessed and are not automatically applied to the other graphs.*

Points

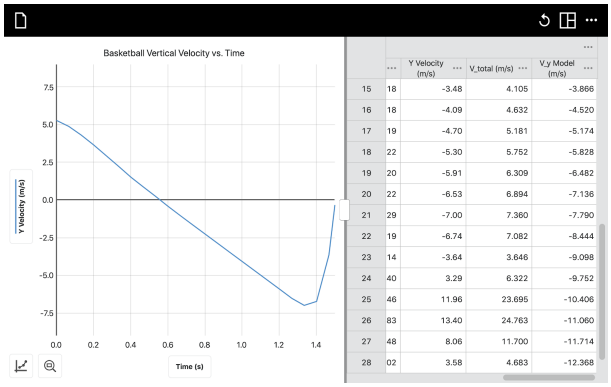
Select Points to show data as unconnected dots.

This is the default option.



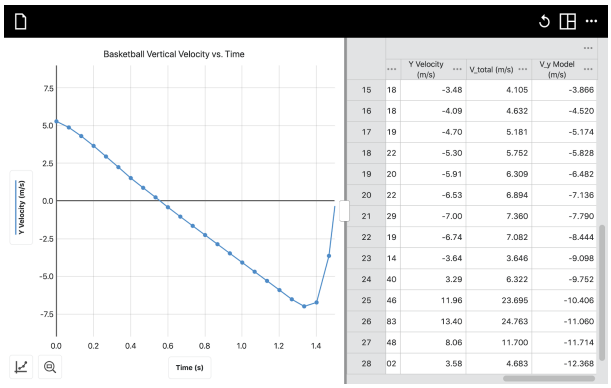
Lines

Select Lines to show linear segments drawn between the data points.



Both Points and Lines

Select both Points and Lines to show data as dots connected by linear segments.



Bars

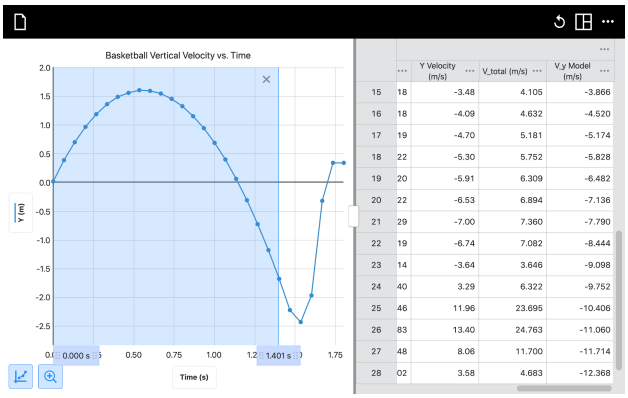
Select Bars to display data as a bar chart. This option cannot be displayed simultaneously with either Points or Lines.

Scaling the Graph

Zoom to a Selected Region

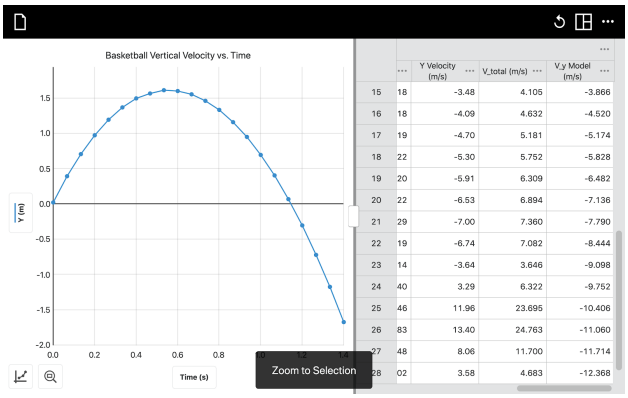
To scale the graph to a specific section of your data, click-and-drag or touch-and-drag across the graph to select the desired region.

TIP! *You can click-and-drag or touch-and-drag the range indicators at the bottom of the graph to adjust the region as needed.*

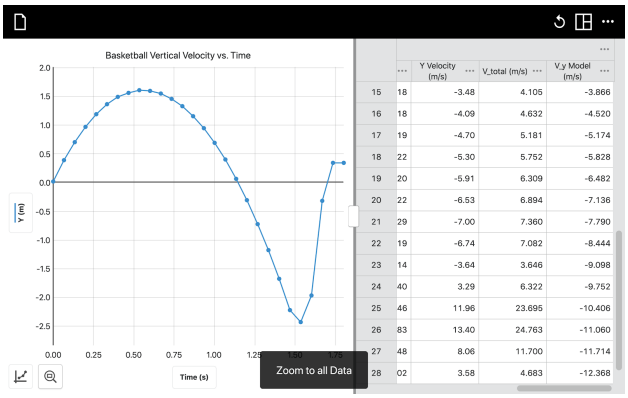


With a region selected, click or tap Zoom to Selection,  , to rescale the graph to fit the selection.

The left and right boundaries match the selected region. The top and bottom boundaries automatically adjust to show all data within the region.



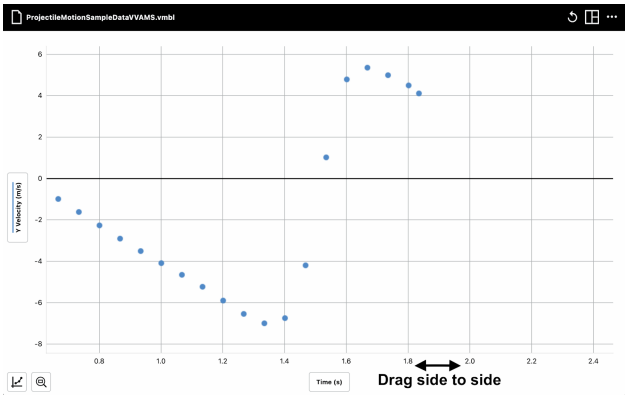
You can click or tap Zoom to All Data, , to rescale the graph to fit all data.



Panning the Graph

Click-and-drag or touch-and-drag near one of the axes to pan or move the graph without changing the scaling. Starting near the horizontal axis (x-axis) pans the graph horizontally. Starting near the vertical axis (y-axis) pans the graph vertically.

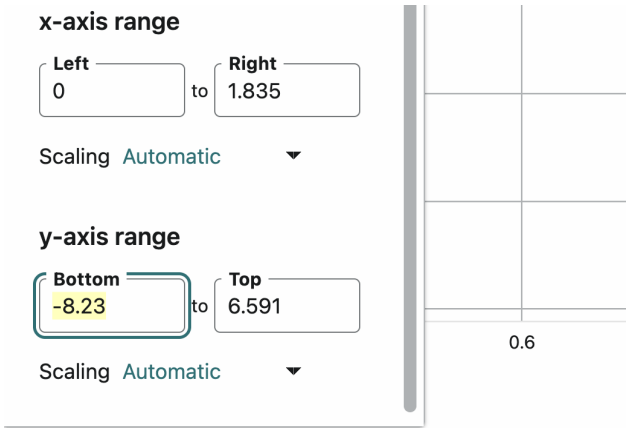
TIP! *Touchscreen devices can use two-finger gestures to pan and rescale the graph.*



Set the Scaling Behavior

Click or tap Graph Tools, , and choose Edit Graph Options to access the graph configuration tools.

Manually configure the x-axis and y-axis ranges to display the data and adjust the scaling as desired. Click or tap Close, ×, to dismiss Graph Options.



Scaling—Automatic

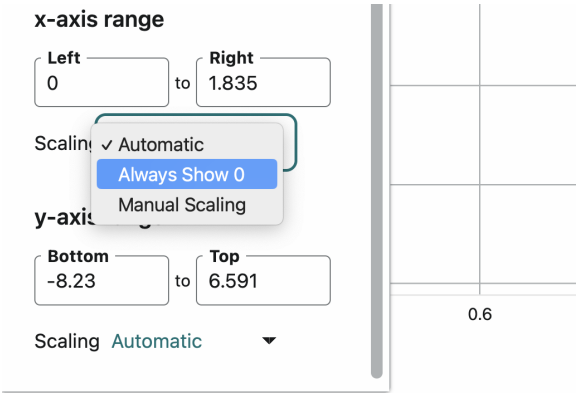
This is the default option. With this option selected, you can still manually enter range values.

Scaling—Always Show 0

This option scales the graph to include 0 for that axis. This setting does not change the automatic behavior related to scaling the graph larger.

Scaling—Manual

This option disables the automatic behavior related to scaling the graph during data point marking only, if set before data marking begins.



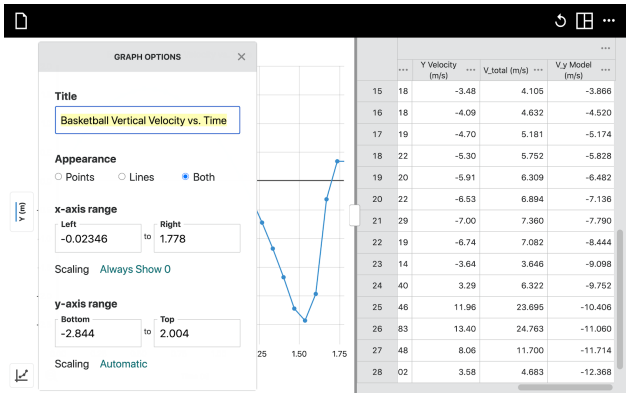
Labeling the Graph

Add a Graph Title

Click or tap Graph Tools, , and choose Edit Graph Options to access the graph configuration tools.

Add or edit the graph title as desired. Click or tap Close, ×, to dismiss Graph Options.

The title appears centered above the graph.



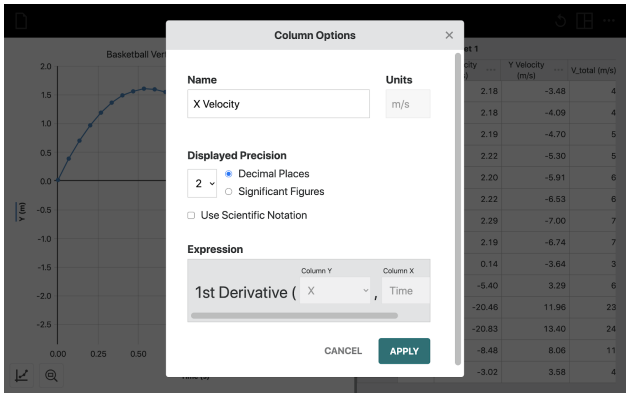
Modify Axis Labels

The axis labels are populated from the column names. You can change the labels by changing the names of the columns.

Open the Plot Manager[3] or the Data Table.

Click or tap Column Options, , next to the column you want to change and choose Column Options.

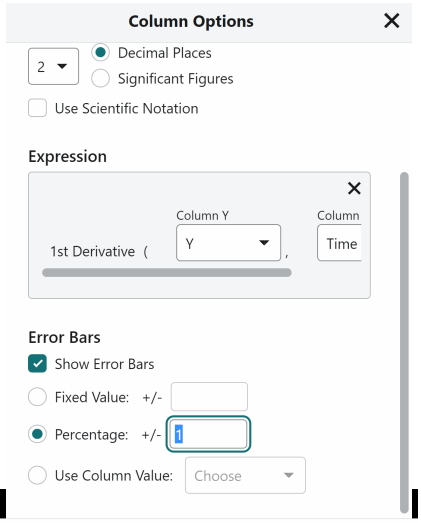
Change the column name as desired. Click or tap **APPLY** to save the changes.



[3] To open the Plot Manager, click or tap the y-axis label.

To change the x-axis label, access the column options for that column from the data table or temporarily plot the column on the y-axis.

Add Error Bars

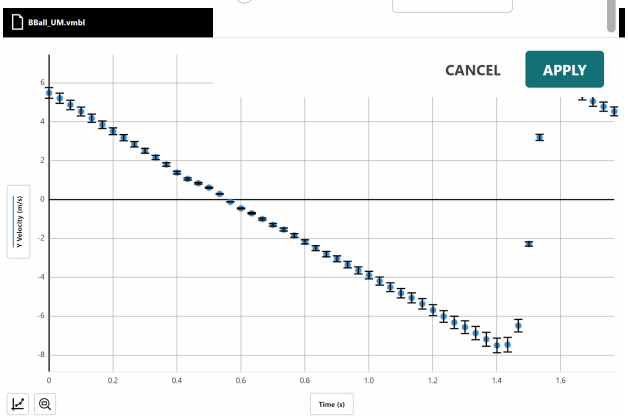


You can choose to display error bars for specific columns of data. Error bars can be calculated from a fixed value, a percentage, or by using a separate column of data. The latter option can be useful, for example, when you have created a manual column of data ranges for a given data point.

Open the Plot Manager[3] or the Data Table. Click or tap Column Options, ⋯, next to the column you want to change and choose Column Options.

Select the Error Bars option to display the ways that error bars can be determined for the data. Choose the appropriate selection and add the necessary details.

Click or tap **APPLY** to save the changes.

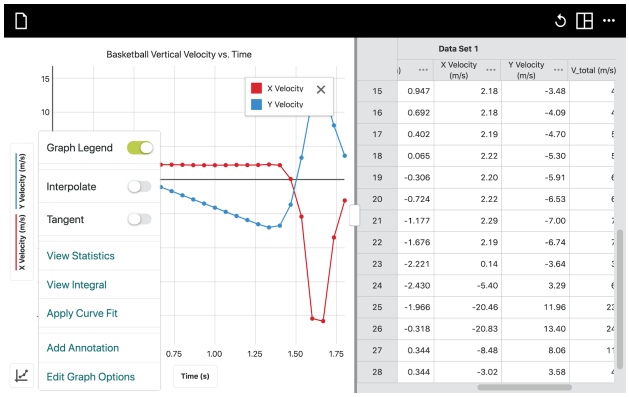


Add a Graph Legend

Click or tap Graph Tools, , and choose Graph Legend. A box showing the color for each column plotted from each data set is displayed on the graph.

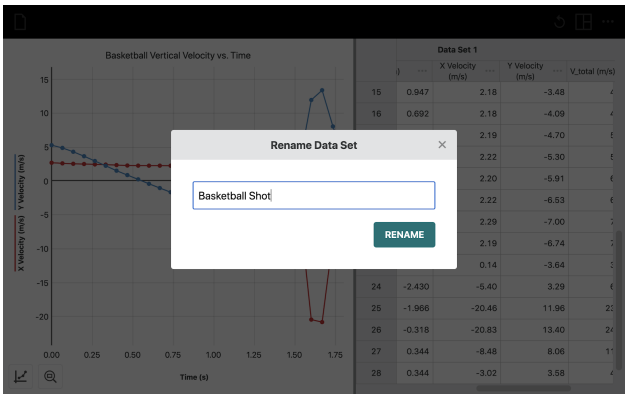
You can drag the legend to reposition it on the graph.

To dismiss the legend, click or tap Close, ×.



Rename the Data Set

While not shown directly on the graph, the data set name is shown in the Plot Manager and the Data Table.



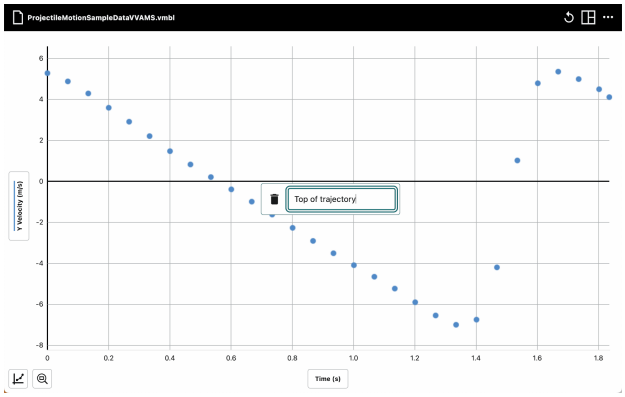
Click or tap the y-axis label. Click or tap Data Set Options, ⋯, next to the data set.

Choose Rename Data Set to change the data set name, and enter a new name.

Click or tap **RENAME** to save the data set name.

Add Annotations

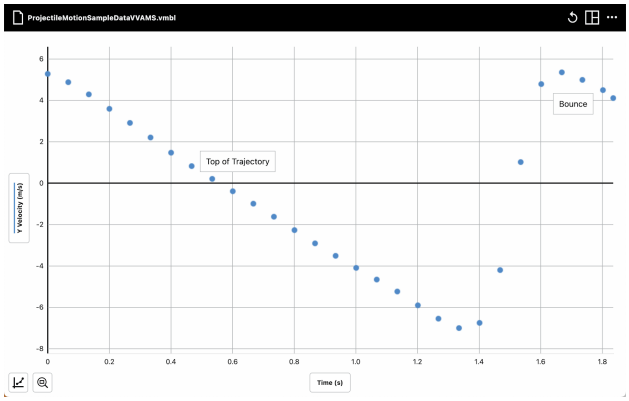
You can add text annotations to your graph to label key points or provide information about the data.



Click or tap Graph Tools, , and choose Add Annotation to add text labels to your graph. Edit the text as desired.

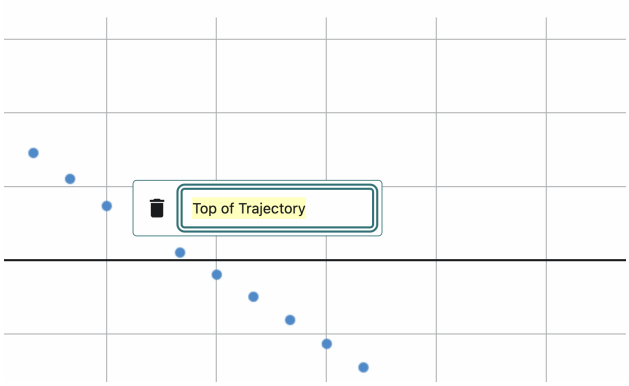
Use Return or Enter to finalize the text box.

Drag the annotation to reposition it on the graph.



Click or tap an existing annotation to edit the text or delete the annotation

Click or tap the trash can, , to delete the annotation.



Configure the View

Vernier Video Analysis automatically displays a view consisting of the video, a graph showing vertical (Y) and horizontal (X) position, and a data table. You can use this default view or modify the view.

Click or tap View, , and modify the options as desired.

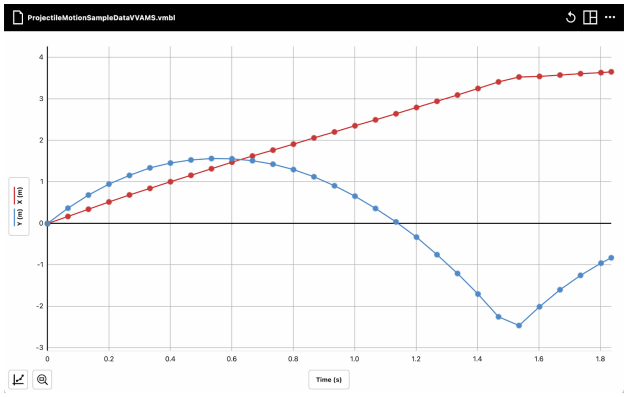
Use Only a Single Display Element

For a full-screen view of a Graph, Data Table, or Meter, turn on the element you want to see and turn off the other elements.

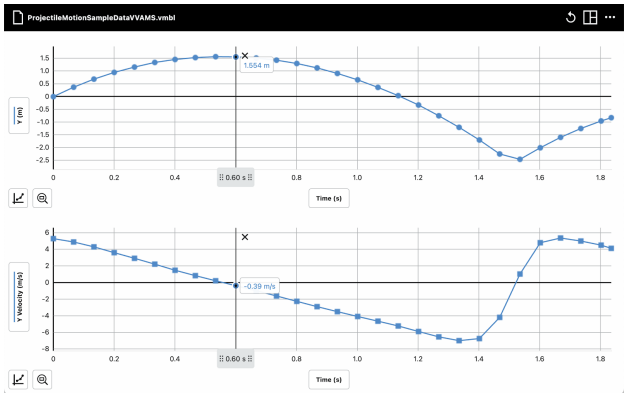
For the Graph element, you have the option of displaying 1 or 2 graphs.

1 Graph

Choose 1 Graph to display a single graph.



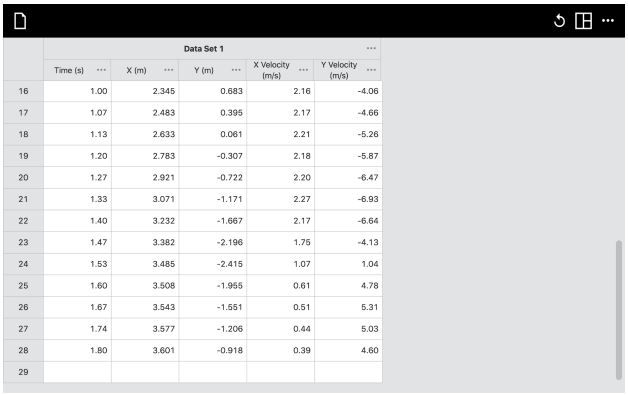
2 Graphs



Choose 2 Graphs to view two stacked graphs. This is particularly useful for simultaneously viewing position *vs.* time and velocity *vs.* time graphs.

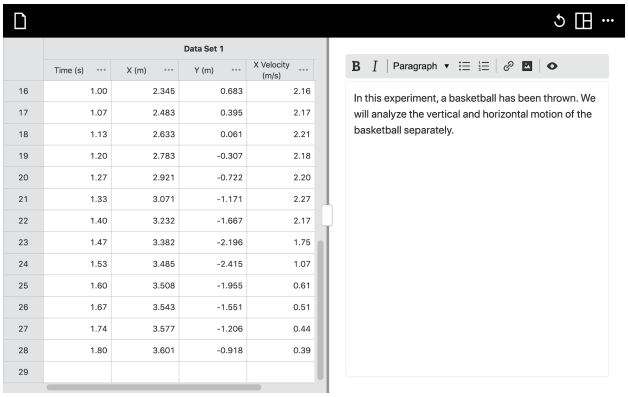
Tip! *If both graphs have the same horizontal axis data, an Examine line on one graph will result in a corresponding Examine line on the other graph.*

Data Table



This view shows the data table. You may need to scroll left and right to see all the columns.

Notes



This element adds a note field. Click or tap the eye, 👁, or pencil, ✎, to toggle between edit mode and view mode.

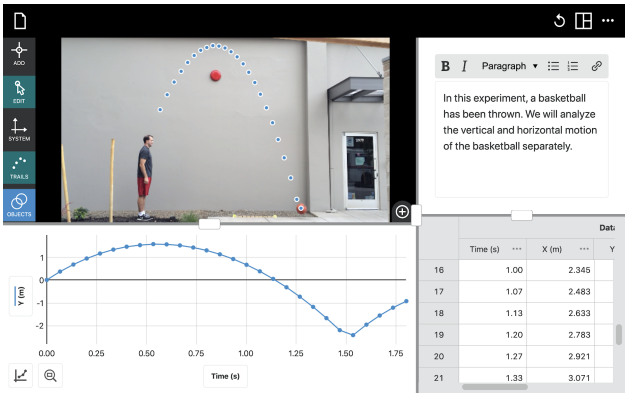
While in edit mode, text is shown with simple markup elements. In view mode, the text is displayed in a larger font and includes any applied formatting.

Images and links can be added while in edit mode.

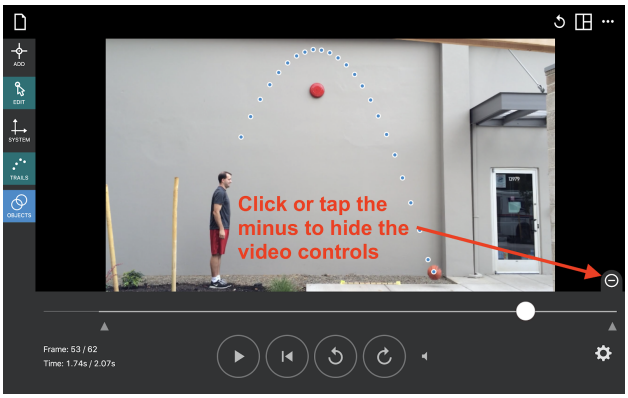
Display Multiple Elements

You can choose to show two, three, or all four elements at once. The splits can be adjusted by dragging the handle located on the lines that separate the elements.

The figure to the right shows all four elements at once. Adjust the browser window to fill the screen for best results.



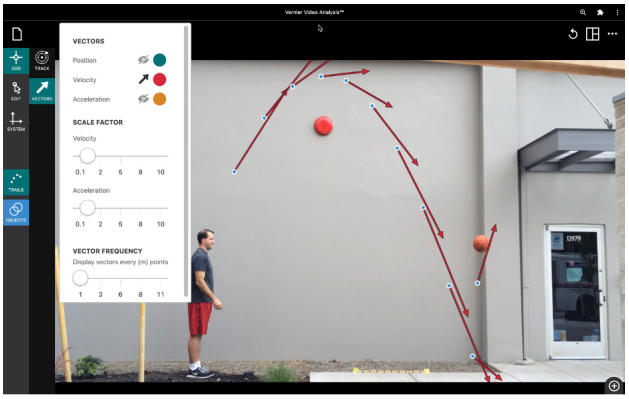
TIP! *Use Minimize, ⊖, to hide the video playback controls. This makes the video itself larger.*



Vector Display

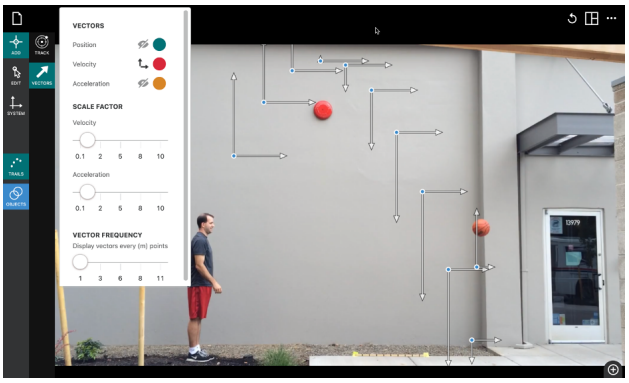
Vernier Video Analysis can superimpose position, velocity, and acceleration vectors on a video with a tracked object. These vectors are determined using the chosen coordinate system and their relative magnitudes from the velocity and acceleration columns. An acceleration column is created as needed for vector displays.

To enable vector display after marking points, click or tap Add, , then Vectors, .



A control panel allows you to show or hide position, velocity, and acceleration vectors and their Cartesian components parallel to the X and Y axes. Click or tap the icon next to the color dot to cycle through the available vector options:

- resultant vector
- component vectors
- resultant and component vectors
- off (no vectors)



Because velocity and acceleration units are incommensurate with the spatial units of the video, an arbitrary scale is used to determine the length of the displayed vectors. Use the Scale Factor sliders to adjust the vectors as desired.

The Vector Frequency slider allows the choice to display vectors on only a subset of points. Choose a setting to allow easy viewing of vectors without overlap.

Notes on the Use of Vector Displays

- Vectors can only be applied to a single object at a time. If there are multiple tracked objects, click or tap Objects, , and select the object of interest. Then Click or tap Add, then Vectors.
- To reduce visual clutter when studying vector displays, you may want to hide the data table and graph using the View menu. It may also be helpful to hide the video playback controls as shown in the screenshots above.
- There are two ways to control the frequency of vector plotting. Generally the preferred way is to use the Vector Frequency control. The alternative is to reduce the number of frames you mark. However, this approach will affect the derivative calculations of velocity and acceleration.

- The velocity and acceleration vectors are drawn proportional to the values in the data table. Because these values are numerical derivatives of the position data, they are *not* instantaneous velocities or accelerations. Instead, they represent an average based on the position values on either side of the point carrying the vector. When an object changes direction suddenly (as in a bounce or impact) the vectors drawn adjacent to the moment of the change may not be what you expect. They may be based on position values on the other side of the change. You can reduce this effect by marking more frames or by reducing the number of points used for derivative calculations (see below).
- Position vectors are drawn from the origin to the object, and therefore change as the origin is changed.
- The vector component directions depend on your choice of coordinate system rotations. If you rotate your Cartesian coordinate system, the components are calculated and drawn based on this rotated system.
- Vectors are only displayed for drawn points. If trails are turned off, only the current visible point will display vectors. If the current time on the video is earlier than any marked points, no vectors are shown.

Modify the Derivative Algorithm

Video Analysis uses an estimation algorithm to calculate the derivative of position data (and subsequently the derivative of the calculated velocity data). The default setting uses a total of 7 data points—the central point and 3 points to either side. To modify this setting, click or tap Other Options, ···, in the upper-right corner of the app and choose Session Preferences. Use the drop down menu to select the desired number of data points to be used in the calculation.

For additional details and an explanation of why you might want to modify this algorithm, please refer to https://www.vernier.com/til/1467

VI. Managing Video Analysis Files

Open Existing Files

Click or tap File, 🗋, and choose Open. From here, you can access files stored on your device; from an accessible cloud storage location such as Google Drive, iCloud, or Dropbox™; or from a connected storage device such as a USB drive or SD card. **Note**: Not all options are available on every platform. You can also choose to open previously saved Vernier Video Analysis (.vmbl) files.

Save Your Work

Save

Click or tap File, , and choose Save to save the current file. This action creates a default file name that starts with the previous name (or "Untitled" if previously unsaved) and appends an underscore followed by a random four digit number to avoid overwriting a previously saved file. For example, saving a file previously named BallToss might result in the Save dialog to suggest a name of BallToss_1234.vmbl.

If your file has never been saved, choosing Save is equivalent to choosing Save As.

Save As

Click or tap File, , and choose Save As to display the Save file box. The file is given a default name of "Untitled_####.vmbl" where #### represents a four digit random number. You can rename the file and select where the file is to be stored. You can save the file directly to your device using the available options, such as an accessible cloud storage location (e.g., Google Drive, iCloud, or Dropbox) or a connected storage device (e.g., USB drive or SD card) depending on your device. **Note**: Save As will not automatically overwrite a previously saved file.

Export Images and PDFs

Click or tap File, , and choose Export. Depending on which elements are displayed, you will have different options. For example, you can choose to export the currently displayed video frame as a .png or .pdf file.

Graph Files (.png)

When exporting, Graph 1 is selected by default (if two graphs are displayed, only the top graph is exported). When exporting a graph, you can select several options to enhance the exported graph file. **Note:** Changes to these settings are reflected on the displayed graph.

- **Line Shade**—this option controls how dark the graph grid and axis lines are drawn.
- **Axis Label Size**—this option controls the font size used for the axis labels.
- **Graph Shape**—this option controls the aspect ratio of the graph image.

Click or tap **SAVE PNG** to save the graph file.

TIP! *You can click or tap Copy to Clipboard, , to copy the selected graph to your device clipboard. Use this feature to paste your graph into a document on your device.*

If you are displaying multiple graphs, you must export each graph separately. Style choices made for your first graph will persist for your other graphs.

TIP! *Use this feature to create images of your data for inclusion in a lab report or for submission to an instructor via file sharing, emailing, or printing.*

Video Files (.png)

This function exports a .png file of a screenshot of the video. It will display identically to the image present on the video.

PDF Files (.pdf)

This feature creates a .pdf file that displays all graphs that are visible, the image visible on the video, and any notes that are visible. You can select from the same enhancement options that are available when exporting a graph file.

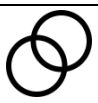
Print

You cannot print directly from Vernier Video Analysis. To print, click or tap File, 🗋, and choose Export to create the desired file (.png or .pdf). Print the resulting file using the print options available on your device.

Start a New Experiment File

Click or tap File, 🗋, and choose New Experiment to start a new file and reset all data-collection parameters. If you have unsaved data, you will be prompted to save the existing file before continuing.

VII. Tool Quick Lookup

	Add: Select to add data points. Also access option for Track (autotracking) and Vectors		Track: Define object to autotrack and start autotracking
			Vectors: Add vectors to marked points
	Edit: Edit marked data by moving it or deleting it.		Trash can: Delete a data point or annotation.
	System: Access the scale and origin tools		Scale: Set the scale and units using a scale object in the video.
			Origin: Move the origin and/or rotate the axes. Toggle between Cartesian and Polar coordinate systems.
	Vectors: Choose which vectors to display, and define the relative scale and frequency of vectors.		Vectors are hidden.
			Vectors and components aligned to the axes are displayed.
			Vectors without components are displayed.
			Only x- and y-components of vectors are displayed.
	Trails: Toggle the display of data points on the video on and off.		Objects: Add a new object, edit the name or mass of an object, edit the color of the data marks for an object, show or hide Center of Mass when two or more objects are tracked, and select which object is being tracked when adding points.

	Advanced Video Options: Change the number of frames to advance the video with each marked point, and change the video frame rate if needed.		Close: Remove the box, view, or object.
	Play the video.		Pause video playback.
	Rewind: The video will go back to the first frame as indicated by the upward-pointing triangle on the scrub bar.		Audio: Toggle the audio track of the video on and off
	Step the video forward one frame		Step the video backward one frame. Also used for Enable Replay.
	Range Indicator: Restrict video playback so only a portion of the video plays; useful when the video is longer than the motion to be analyzed.		Hide or view the video playback tools.
	File: Start a new experiment, open a saved experiment, save your work, or export graphs or data.		View Options: Adjust the view to include the video, one or two graphs, a data table, and/or notes.
	Information: Learn more about the selected function.		Axis label on a graph: Change which data are plotted on your graph.
	Graph Tools: Access data analysis tools and change the graph style.		Zoom to all data or to a selected portion of a graph.
	Options or Settings: In any situation, this menu shows additional functions. On the main screen, click or tap to determine license information, modify the derivative calculation, access the user manual and the app distribution tool, toggle dark mode, and see what is new in the current version. When this icon is shown next to a column name or data set name, click or tap the icon to access menu options specific to columns or data sets.		

VIII. FAQs

Can Vernier Video Analysis be used offline/not connected to the internet?

Short answer: Yes, for up to two weeks.

Longer answer: When the app starts up, it checks to see if there is a current valid key. The app will consider the key to be valid for two weeks after being checked, and after that time elapses, the app will check to see if the key is still valid. If the device running the app is connected to the internet during those two weeks, it will automatically revalidate the key when the app is started up. This means that the app can be used while a device is not connected to the internet for two weeks, provided it was last used while connected to the internet. After two weeks, the app will need to connect to the internet again to revalidate the key.

I saved my file to my Google Drive. When I try to open the file, why does it look like code?

To re-open a file in Video Analysis, first open the app. Then click or tap Open File and navigate to the location where the file is saved. Select the file and choose open. Note that files created by Video Analysis have the suffix .vmbl. Double-clicking a .vmbl file will generally not launch the Video Analysis app, unlike some other applications.

I accidentally closed the browser window/tab while analyzing a video. Can I retrieve my data?

If you try to close a tab with unsaved Vernier Video Analysis, the browser will warn that work is unsaved and ask to confirm you want to leave the tab. If you do leave the tab, your data will be lost. You will have to collect data again. This is also the case if the browser or device crashes during your session, or if you quit the browser.

Which video formats are supported?

Compatible file types include .mp4 and .mov. These containers may hold videos compressed with incompatible codecs, so some of these files may not be usable. For example, iOS devices can collect videos in a high-efficiency format called HEVC. Many other devices, such as Chromebooks, cannot open these files. Record videos on Apple devices using the “Most Compatible” choice, available in Camera Settings. You can convert a video to the correct format using commonly available resources. For more information, see https://www.vernier.com/til/1342

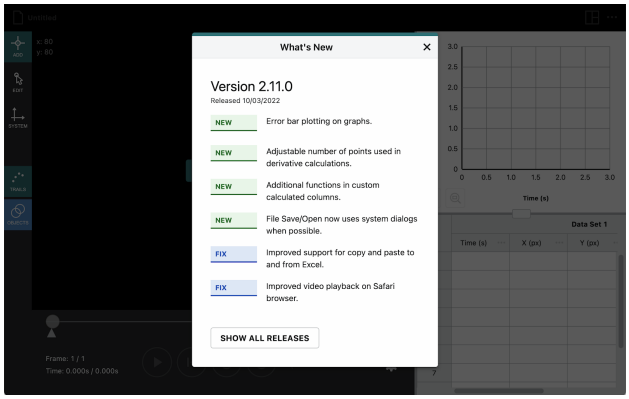
Do I need to update Vernier Video Analysis?

Vernier Video Analysis automatically updates when opened if there is a software update available and the device you are using is connected to the internet. There is no need to manually update the app.

Where can I find out what is new in the app?

Click or tap ··· from the top toolbar and choose What's New to view a summary of the new features and fixes available in the most recent version of Vernier Video Analysis.

Click or tap **SHOW ALL RELEASES** to see changes made in previous versions.



Where can I find additional help?

For up-to-date information, see https://www.vernier.com/til/7037

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