Video analysis Tools

We know that professionals, whether in sports, research, or healthcare, demand that any new technology that provides the opportunity to make measurements, those tools must allow the user to become productive quickly, without long learning curves and without sacrificing the ability to obtain accurate data. The video camera along with video analysis software has become one of those tools. In this project you will become familiar with a physics open source piece of software called **Tracker**. This free software package will allow you to analyze any video clip that you have obtained from most video source (from video camera to cell phone camera) and quickly analyze the motion, trajectory, or the intensity of the object the video sequence has recorded. This data then can be plotted, graphed, examined, exported to other software so you may verify a property of science or even discover new ones (remember the Nobel prize comes along with a cheque for over one million dollars).

Phase 1

The first part of this project will be for you to visit the following **Tracker** website:

http://www.cabrillo.edu/~dbrown/tracker/

You can also visit the WCI Physics Site and we will provide links for you to **Tracker**

Your first step will be a download the **Tracker** (Java based) software onto your computer (**Tracker** should be available on most school computers). Once you have started tracker, revisit the **Tracker Home Page** and click on the **Help Getting Started** link and follow the instructions step by step. This will allow you to become familiar with the software and most of its capabilities.

Click on **Help Getting Started**
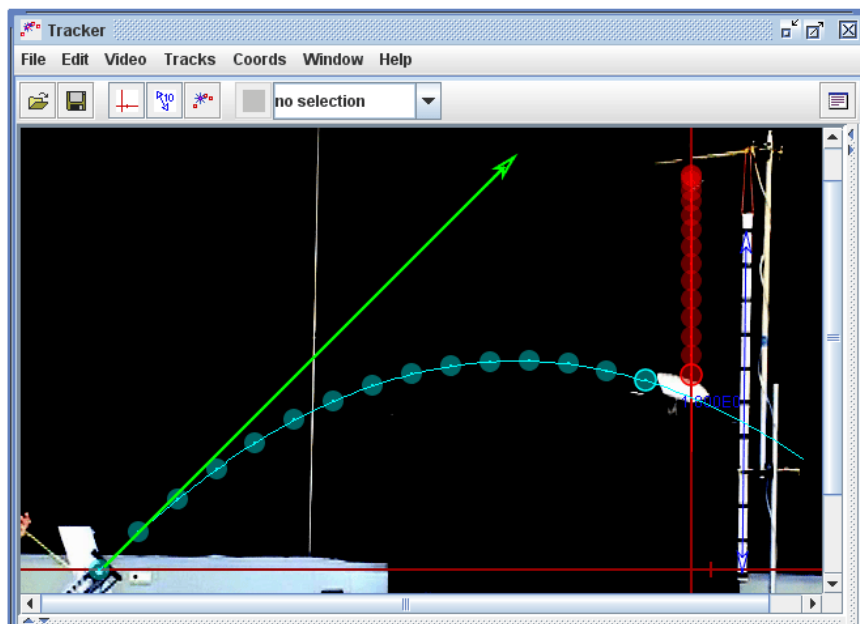
Ensure that you visit the following lessons

1. **Open a video or tracker file.**
2. **Identify the frames ("video clip") you wish to analyze.**
3. **Calibrate the video scale.**
4. **Set the reference frame origin and angle.**
5. **Track objects of interest with the mouse.**
6. **Plot and analyze the tracks.**
7. **Save your work in a tracker file.**
8. **Export track data to a spreadsheet.**
9. **Print or copy/paste images for reports.**

On step two "**Identify the frames ("video clip") you wish to analyze.**" You should download some of the sample videos that Track has provided.
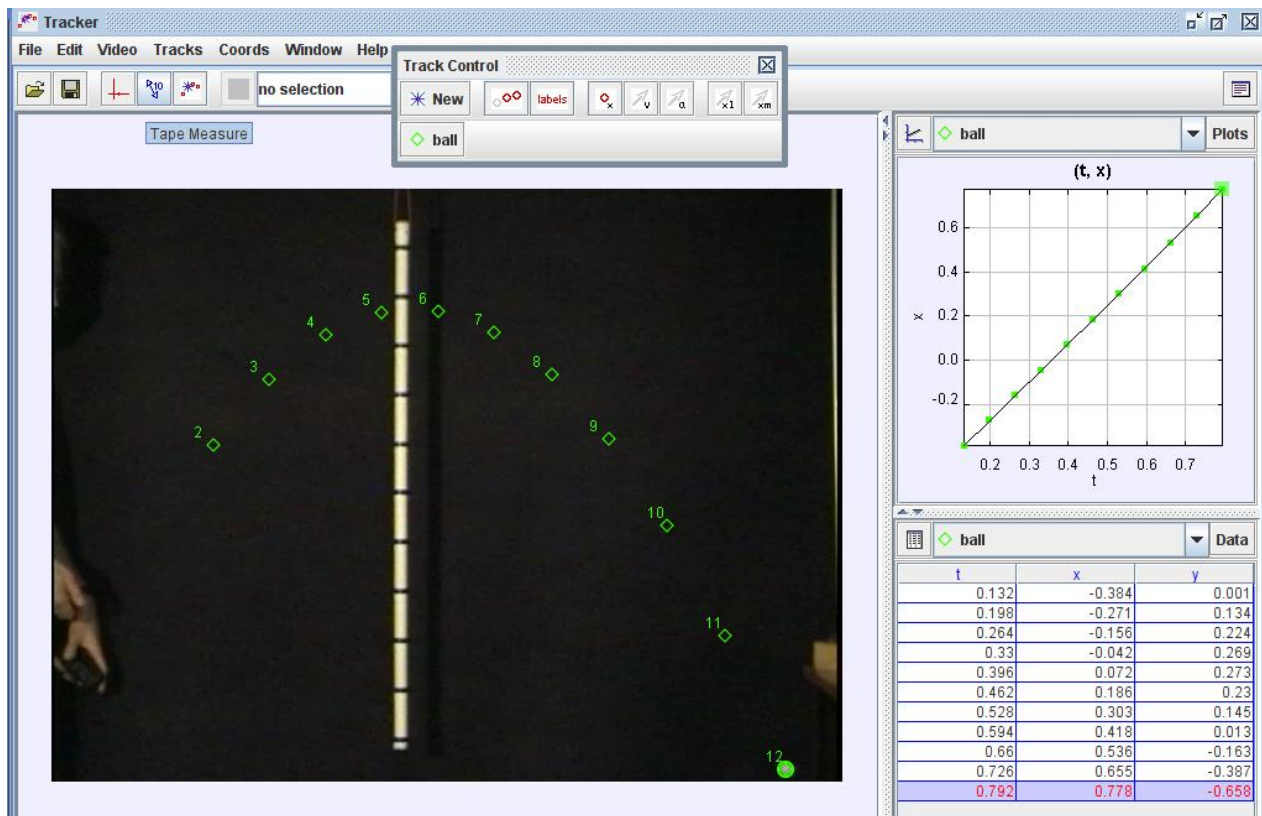
These videos are located on the Home page of tracker under the heading of:

- **Web Start sample video experiments**

Phase 2

Download the : **Ball Toss** example video from the **Sample Video Page**

This video demonstrates the tossing and catching of a ball, along with 11 data points being selected.

On the right side of the screen are two windows (one with a graph, and one with spreadsheet data). The spreadsheet data contains the *time (t), x-coordinate (x),* and *y*-coordinate (y) for each of the 11 data points. The graph contains the default plotting of position (*x*) versus time (*t*).

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Phase 3

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In this phase you are going to investigate the properties of the tossed ball by answering the following questions. This phase will demonstrate the usefulness of video analysis software in discovering physics properties. Produce a clear well organized report that contains the solutions to these questions.

Question 1

Looking at the graph of x vs t, we notice that it is in a strait line starting at (0,0) and ending at (0.8, 0.8). Keeping in mind that the graph is only comparing the *x* (horizontal) position of the ball as a function of time.

- What can you say about the horizontal motion of the ball?
  - o Is it zero, constant, speeding up (accelerating), or slowing down (decelerating)?
- Compare your above answer to why the shape of the graph is a straight line.

Question 2

By recalling that velocity is $\dfrac{\text{distance}}{\text{time}} = \dfrac{x}{t}$, determine the horizontal velocity of the ball.

- Is this velocity the same for any choice of x positions and times during its journey (this answer should make sense with the answer you obtained from Question 1 above) ?
- Write out the equation of the line of x vs t (you can make tracker do this for you, try right clicking on the spreadsheet data and select **analyze**)
- From your math classes, how does this equation of the line compare to the velocity value you obtained?

Now by holding down the left mouse button on the x column marker on the graph **Tracker** will provide you with more graphs to choose from. Select the **vx** (velocity x-component). The graph of horizontal *velocity vs time* should now appear
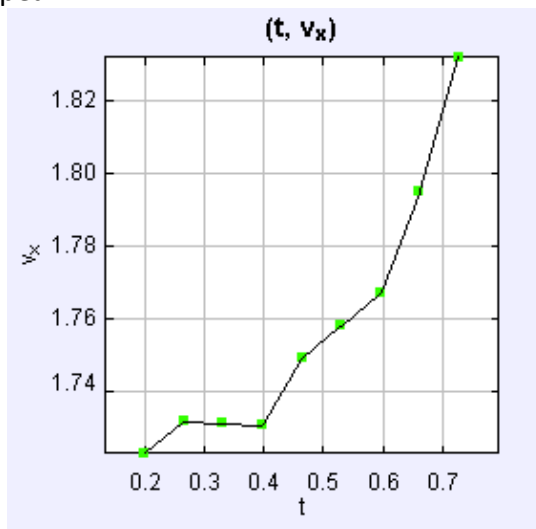
Hopefully, this is not the shape of the graph that you might of expected.

- What did you think the shape of the *horizontal velocity* should have looked like?
- Can you think of a reason why the graph did not match your answer to above (look at the *vertical* scale)

You can have **Tracker** give you the horizontal velocity at every point on its journey by right clicking on the **data** title on the spread sheet and choosing **vx** (velocity x-component)

- Does this data help explain why the line wasn't straight?

Remember we can never created an idealized set of data points and sometimes computer and software are too smart for themselves, we will choose a more appropriate scale for the vertical velocity axis, as **Tracker** (by default) auto-scales the data (this is like a zoom key for data, even the straightest line will look wiggly is you zoom in far enough). *Right Click* on the graph and choose Scale, this will popup another menu and turn off the Auto checkmarks on the data and enter -10 and the min value and 10 as the max value for the horizontal velocity.
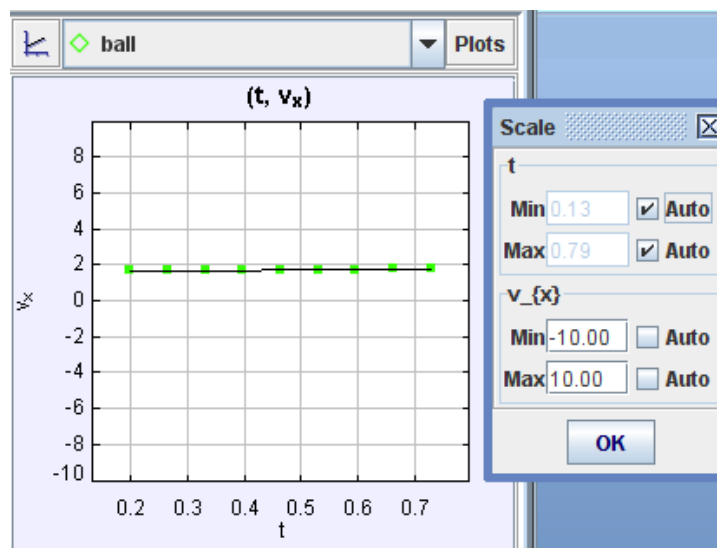
- Now look at the graph, is this more like what you were expecting?

Question 3

Tracker will use the last scale that you used. If you would like **Tracker** to **Autoscale**, just right click on the graph and choose **Autoscale**.

By recalling that accelerating is $\dfrac{\Delta velocity}{\Delta time} = \dfrac{v}{t}$, determine the horizontal acceleration of the ball.

- Is this acceleration the same for any choice of v positions and times during its journey (this answer should make sense with the answer you obtained from Question 2 above)?
- Does this value of horizontal acceleration make sense with tossing of the ball, explain?

Now by holding down the *left mouse button* on the *x* column marker on the graph **Tracker** will provide you with more graphs to choose from. Select the **ax** (acceleration x-component). The graph of horizontal *acceleration vs time* should now appear .

Remember to choose scales (-10 to 10) that make logical sense, This should produce a graph that matches your above answer.

In the new few questions, we are now going to look at the *velocity* and *acceleration* from a vertical (up and down) perspective.

Question 4

Have **Tracker** select *y vs t*, (Don't forget to turn on **Autoscale**)

Looking at the graph of *y vs t*, we notice that it is in a strait line starting at (0,0) and ending at (0.8, 0.8). Keeping in mind that the graph is only displaying the *y* (vertical) position of the ball as a function of time.

- What can you say about the vertical motion of the ball?
    - Is it zero, constant, speeding up (accelerating), or slowing down (decelerating)?
- Compare your above answer to why the shape of the graph looks likes a parabola.

Have **Tracker** display the *vertical* position and time in its spreadsheet (**data**)

Have **Tracker** select the data (*double-click* in the spreadsheet)

Have **Tracker** popup the analyze window (*right-button* **analyze**)

Tracker will popup a window with a graph similar to the one in **Tracker**
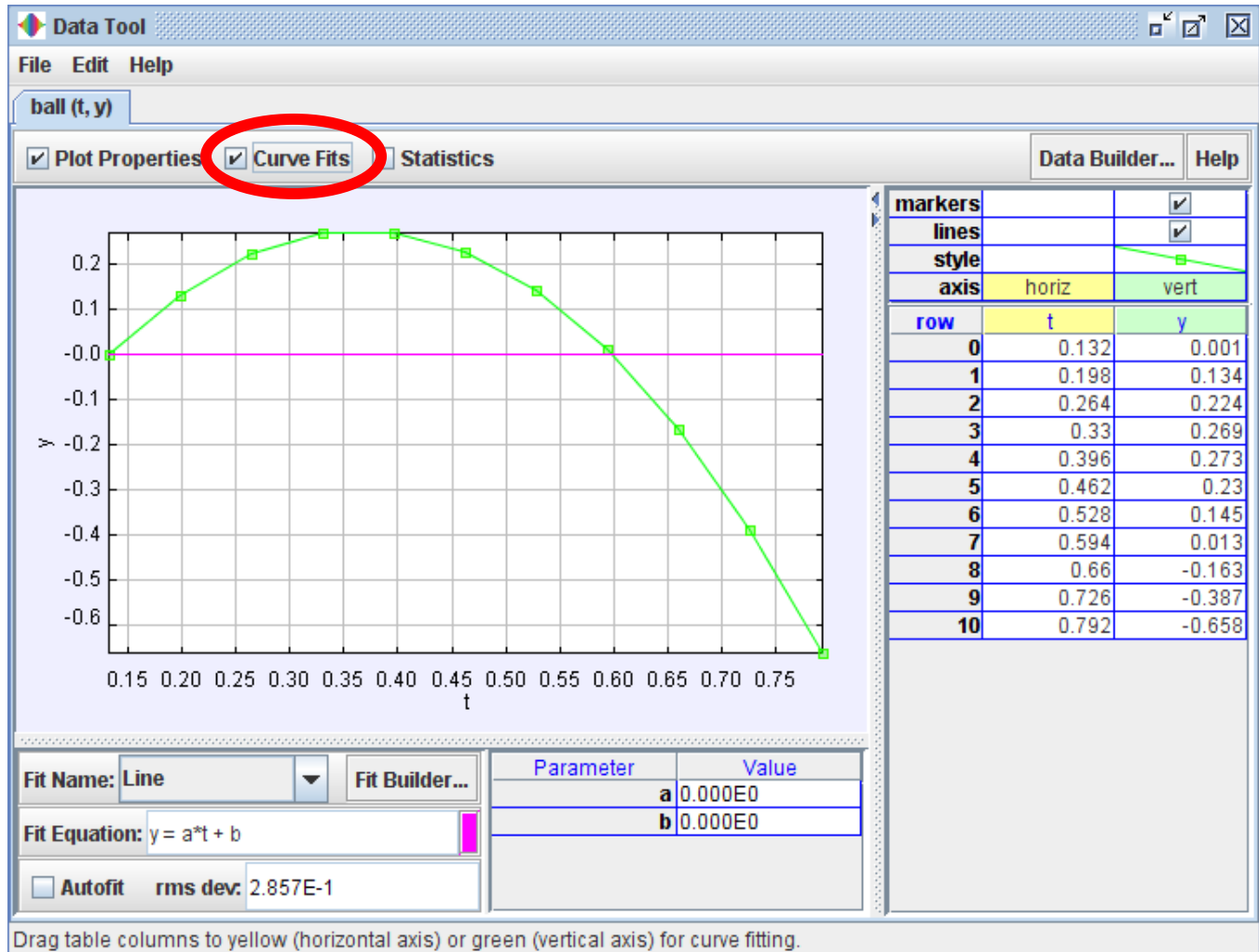
Ensure that **Curve Fits** is checked.

We will now have **Tracker** determine the equation of our parabola.

Change the **Fit Name**: from *Line* to *Parabola*
Now click on the **Autofit** square, and **Tracker** will determine the equation of the parabola

- Using your math skills, determine the equation of the parabola from the curve(show your work) and compare your answer to the equation **Tracker** came up with.

Question 5

By recalling that *velocity* is $\dfrac{\text{distance}}{\text{time}} = \dfrac{y}{t}$, determine the *vertical velocity* of the ball at a few points.

- Is this *velocity* the same for any choice of *x* positions and times during its journey (this answer should make sense with the answer you obtained from **Question 4** above) ?

Have **Tracker** display the y component of the *velocity* in the spreadsheet (did the numbers match yours)

	ball		Data
t	**y**	**vy**	
0.132	0.001		
0.198	0.134	1.689	
0.264	0.224	1.026	
0.33	0.269	0.37	
0.396	0.273	-0.296	
0.462	0.23	-0.971	
0.528	0.145	-1.647	
0.594	0.013	-2.331	
0.66	-0.163	-3.026	
0.726	-0.387	-3.748	
0.792	-0.658		

- Have **Tracker** display the *vertical velocity vs time* graph and determine the equation of the *vertical velocity*. Copy these into your report (you can always use *Shift Print-Scrn* on your keyboard to copy the screen and then start **Microsoft Paint** and paste the screen image into **Paint**, then select the region you would like to copy from the screen image and paste that into **Microsoft Word**)
- What is the shape of the *vertical velocity* graph?
- Why (what of forces are acting on the ball from a vertical perspective) is the shape of the *vertical velocity* graph different from the *horizontal velocity* graph?
- What do you think the slope of the *vertical velocity* graph represents?

Question 6

- By recalling that *accelerating* is $\dfrac{\Delta velocity}{\Delta time} = \dfrac{v}{t}$, determine the *vertical acceleration* of the ball.
- Is this *acceleration* the same for any choice of *v* positions and times during its journey (this answer should make sense with the answer you obtained from **Question 5** above)?
- Does this value of *vertical acceleration* make sense with tossing of the ball, explain?
- Have **Tracker** graph *vertical acceleration vs time* and determine the value of this function?
- What does this value of *vertical acceleration* represent?
- Compare the answer you obtained from the *horizontal acceleration* to the answer you obtained from *vertical acceleration*. Can you justify why the *horizontal acceleration* value was zero while the *vertical acceleration* value was not?

Phase 4

In this phase you will analyze the video ball drop.

I recommend that you use the **Help Getting Started** procedure to create the data point for the falling ball. It will take a couple of tries until you start becoming comfortable with the software using a video of an event.

Free Fall - Insignificant Air Resistance

- The meter stick taped to the door frame to the right in the movie clip should be used for scaling purposes.

- It is probably best to mark the center of the ball in each frame.

- The origin should be placed at either the highest or lowest position marked.

- *Vertical (y) position* values can be translated so that downward movement is defined to be either positive or negative.

- *Horizontal (x)* values of the position are not needed since the ball exhibits only *vertical* movement.

- A position-time plot should be *parabolic*.

- After obtaining the equation of the *position-time* plot, the coefficient of the square term should be one-half of the *acceleration* of the ball, or approximately ±4.9.

- A *velocity-time* plot should be linear with slope equal to the ball's *acceleration*, or approximately ±9.8.

Remember for the following questions, we are only examining the *vertical* component.

Write a one page report on the video the ball drop.
You will include images of the *position vs time* graph, *velocity vs time* graph, and *acceleration vs time* graph in your report. Also, you should determine the equation of the *position* graph, the *velocity* graph and the *acceleration* graph. Remember have **Tracker** do most of the work for you.