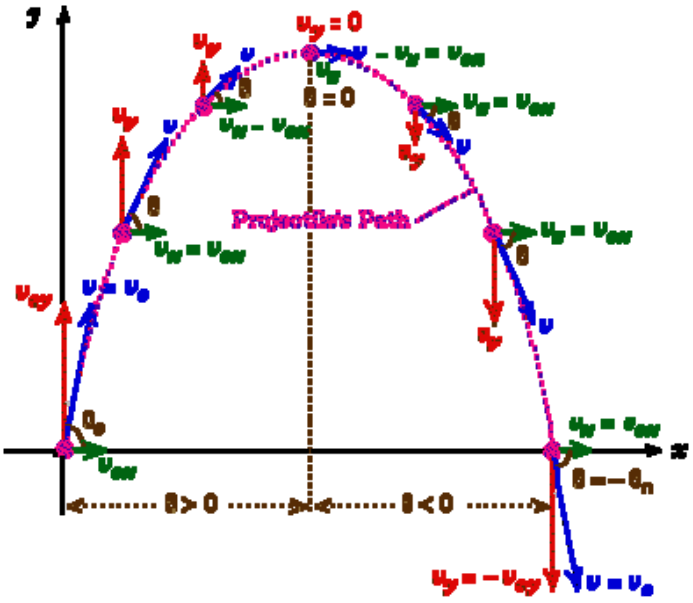
Tracker

The Instruction Manual



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1....Installing Tracker

Tracker can be located a couple of ways, the first way is to use the "Google" search engine and search for "Tracker Physics", the first link will be the one that you want.

A direct link to the tracker program is:

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

On the right hand side of this website is a number of links. The first one you need to grab is number 2 which says "Download Tracker". Click on this link and then click save to save the tracker program wherever you want it.

Tracker has an extension of ".jar" which is a java program. To run it, this means we need to grab the latest version of java as well. There is a link to java on the tracker website (see the note near the top of the links), or the direct link is below:

http://java.sun.com/javase/downloads/index.jsp

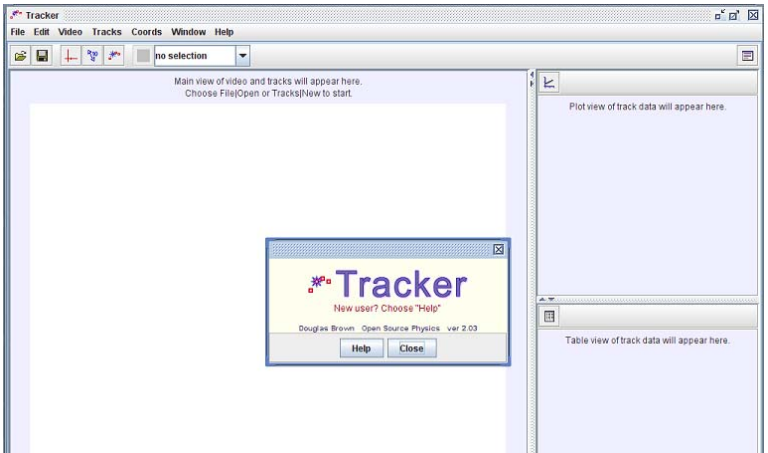
(On this website there are about a thousand different downloads for different versions of Java, if you are a regular user than you want to download just the Runtime Environment (JRE) link. The links that have SDK or JDK ore "Developers Kits" which you don't need to worry about.)

Finally, Tracker is used to analyze videos and uses the Quicktime format for its movies, so you also need the latest version of Quicktime. Again, there is a link from the tracker website (in the same note as the java link), or use the direct link below:

http://www.apple.com/quicktime/download/

Finally, if you want to be able to follow the tutorials included in this instruction manual, and then download the sixth link on the Tracker website: "Download Mechanics Videos", which is a zip file containing some sample mechanics videos for analyzing. Just save it in the same directory as the actual Tracker program and unzip it there as well.

Whew! After all that you should be ready to go, just double click on the tracker .jar file and if you see the window below, you are all set!



2....Setting Up Videos for Analysis

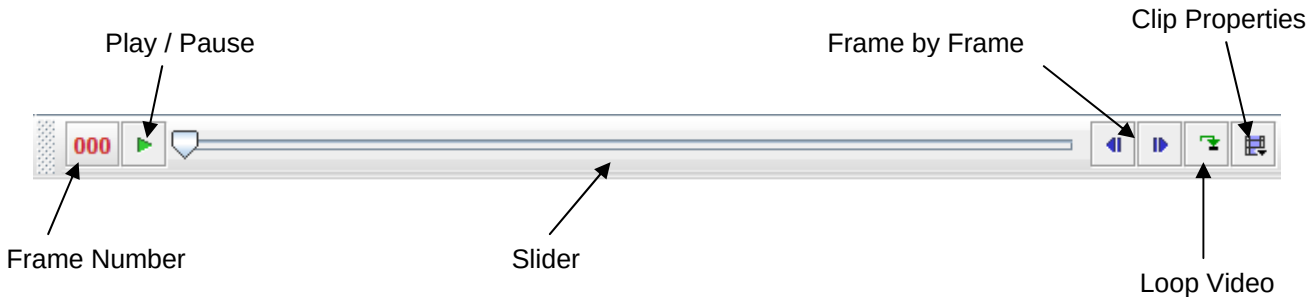
Firstly, Tracker can't open every single format of movie that exists, but it can open anything that Quicktime can open. This includes the Quicktime movie format (*.mov) as well as compressed video (*.avi, including DivX), unfortunately Tracker does not support MPEG (*.mpg) or Windows Video (*.wmv).

Secondly, for best results the video that you want to analyze should be shot from a stationary camera (one that doesn't move with the action) and have some sort of reference for calibrating distance. This will make more sense later on in the manual…

Once you have a video in the correct format for Tracker you can open it simply by going to "File…Open" and selecting the video file that you wish to view. The video should appear in Tracker and should play as well.

For now, open the file "BallTossOut.mov" from the downloaded mechanics videos folder.

The first thing you want to do once you have a movie opened is to clip out the portion that you want, and set the interval for time speed (how many frames per second is the video shot at?) To do this we need to look at the control bar at the bottom of the screen.



Click on the "Clip Properties Button" to pull up the Clip Settings window. The first thing to do with this window is set the start and end points that we want to use of the clip (remembering that the video starts on frame zero, not frame one). Type in a frame number and press enter in either the start frame or the end frame box and you should see the preview frames change accordingly. You can also change how many frames the "step size" is, but for most purposed one frame at a time at a time is what you need.

Below this row is another three options for start time, step *dt*, and play rate. These first two are used in the physics calculations that the program can do, and usually you want to leave the start time at zero seconds (but you can start at any time you want). The step *dt* though is very important. This tells the program how much time elapses between frames. To find this value you need to know what the frames per second of the video are, most cameras shoot video at either 25 or 30 frames per second. Then, to get the seconds per frame, just take the inverse of this value.

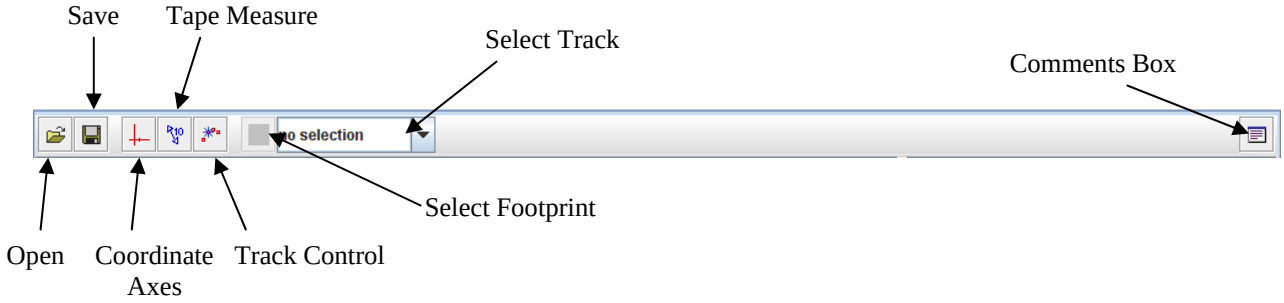
For example:

$$20\,\text{frames per second} = \frac{20\text{ frames}}{1\text{ second}} \quad \text{or} \quad \frac{1\text{ second}}{20\text{ frames}} = .05\text{ seconds per frame}$$

For the ball toss video we have opened set the start and end frames as 9 and 30 respectively and leave the step *dt* as .033 seconds which corresponds to 30 frames per second.

Now that we have set the time parameter of the video we want to analyze we need to set the space parameters of the video. This involves two steps, calibrating the length, and setting up our coordinate axes.

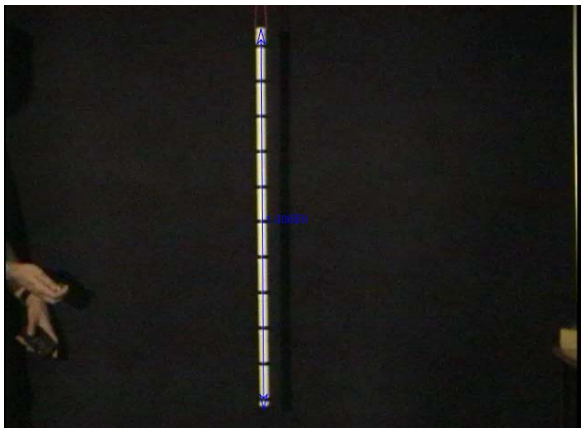
Firstly, we want to calibrate the length, to do this we need to examine the top toolbar.

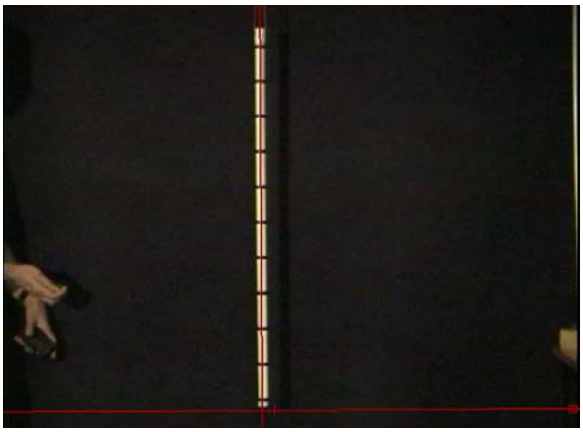


To calibrate the length click on the tape measure button and you should see a blue double arrow appear on your video. This is your tape measure that you need to calibrate length. To calibrate the length click on the middle of the arrow to move it, or either end to drag the ends where you want them. Drag it so that the arrow is of a length that you know, and then double click the number associated with that arrow and enter in the length in meters, press enter and voila, the length scale of your video should be calibrated. For best results, include some feature in your video that allows you to calibrate length (like a meter stick located somewhere in the frame).

Next we need to set the coordinate axes for the video; this provides a frame of reference when the program does its calculations. To do this click on the coordinate axes button and you should see a red set of axes appear. Click on the origin to drag these axes around the then click on the positive x-axis to rotate them. You can position the axes anywhere that you want, but it is usually helpful to pick someplace meaningful from your footage.

Calibrate both the length and the coordinate axes for the ball toss video using the meter stick in the middle of the frame as your reference for length and the bottom of the stick as your origin for the axes (give the axes a slight rotation to match the meter stick.) You should have something that looks like the following:





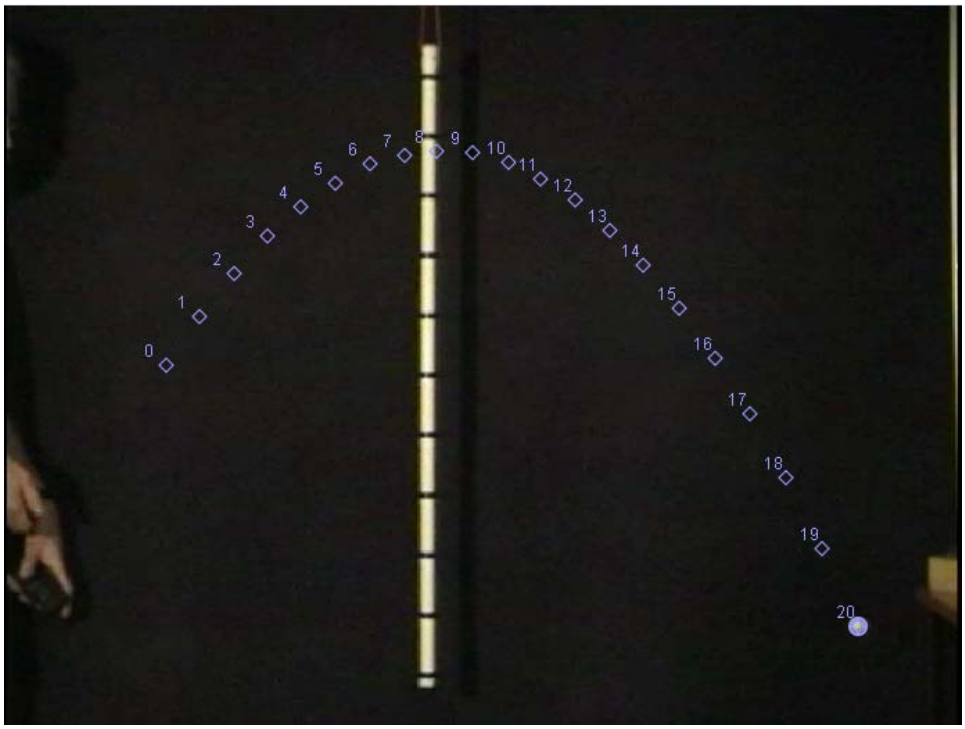
That's it! The video should now be ready to analyze. There are a few more things that you can do. You can zoom the video by right clicking on it and selecting the zoom level. Pull down in the Track Selector either the tape measure or the coordinate axes and then click on the Footprint Selector button where you can change the color or the look of the objects. You can also click under "Video…Filters" and apply various effects to your video to change its look. These are some of the various options that you can play around with.

3….Tracking Individual Masses

Now its time for the fun to begin! This is where the meat of the analysis is, after the video has been set up you need to actually track the masses that you want to analyze. To do this click on "Tracks…New…Point Mass" and you should now have the option to pull down "mass A" in the

track selector. (You can also click on the track control button and create a new track for the mass from the new window that appears. Tracking individual masses is quite simple after this. Make sure that you have selected the track you want (mass A, or something else) and simply start at the first frame of your video, hold control, and click on the mass. Notice that with "mass A" selected, the cursor becomes a box when you press control, and after clicking the mass the video advances one frame and leaves a trail of the mass that you are tracking on the screen. All you have to do at this point is control-click the mass on every frame that you are analyzing.

Do this for the ball toss video from section 2 and you should end up with the following:



That's it! Simply repeat this process for each mass that you wish to track. Now Tracker has all the information that it needs to do all of the calculations that you could ever wish for. The next sections will detail how to extract this information from the program.

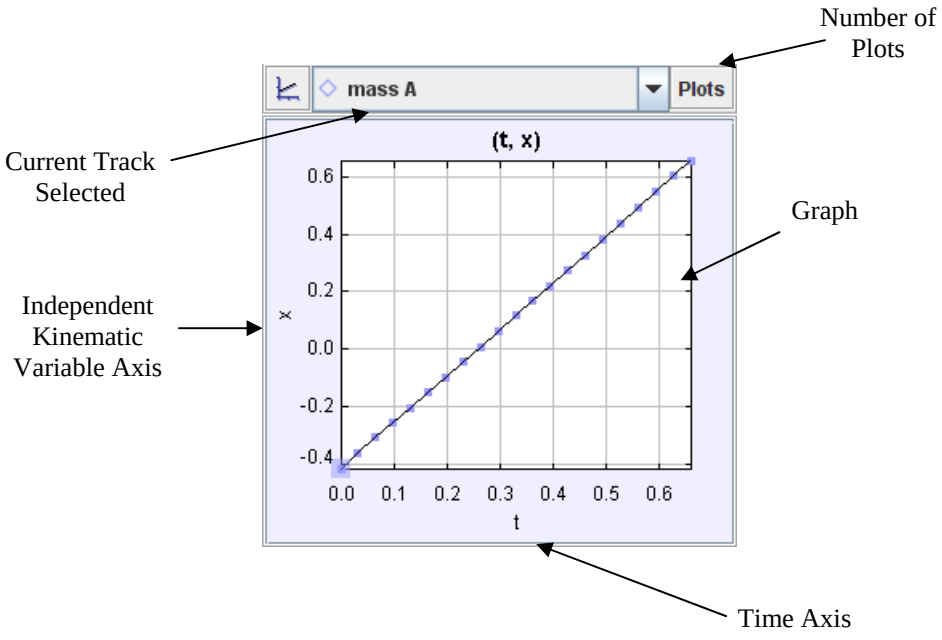
An additional feature which can be fun to play with is located in the track control window (from the main toolbar). Select whichever track you want in this window and then notice that there is are buttons at the top that say x, v, and a, and have either a point (for x) or an arrow (for v and a).

This lets you toggle what information Tracker is showing. Try clicking on the v or the a arrow buttons and watch as Tracker automatically draws in the vectors on the video screen. The last buttons on the right hand side of this window will either multiply the lengths of these arrows (1x, 2x, or 4x) and multiplies the vector by mass respectively. Note that when you multiply the velocity vector by mass you get momentum (p = mv) and when you multiply the acceleration vector by mass you get the force (F = ma).

4....Graphing Kinematic Variables

One of the most useful features of the Tracker program is its ability to display graphs of the various kinematic variables that you would want to analyze. To do this, simply look at the right hand side of the screen. You should see a window with a graph already there; if you do not see it then you have it hidden. To hide/show this graphing window simply look for the set of arrows that looks like below:

You can simply click the left facing arrow to show the graphing/data window, or click the right facing arrow to hide it. The graphing window, once its shown, looks like the following:



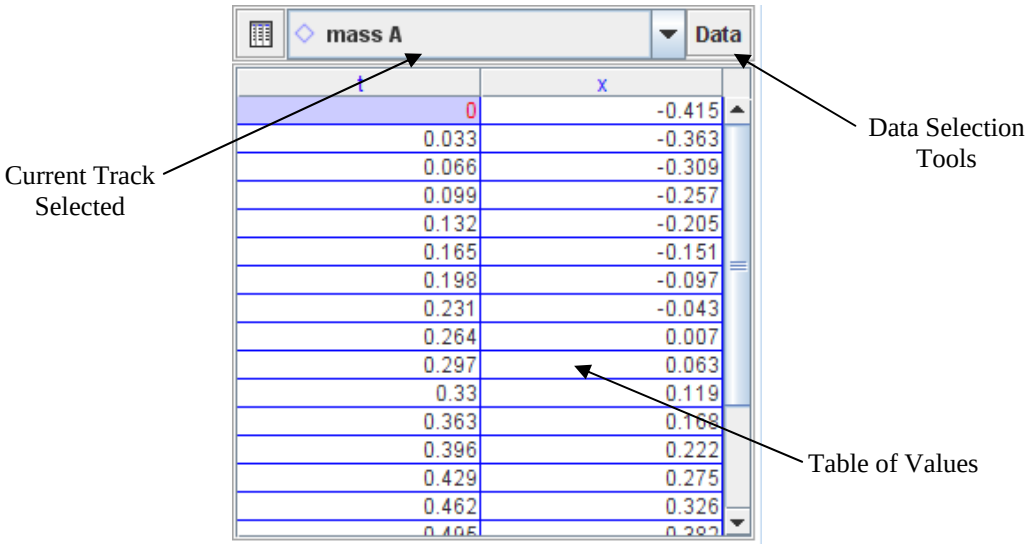
You can change which track you have selected (and are viewing the data for) from the top pull down menu and you can change the number of plots (either 1, 2, or 3) that you are showing at a time from the button in the upper right hand corner.

To change which variable that you are viewing the graph for, simply click on the independent variable and a list should pop up, then click on whatever variable you wish to view. Typically you want to see how these variables change with time, but you don't have to! You can click on the time axis in the same way and plot whatever variable on the independent axis that you want. For example, you can look at how position varies with time, or how position varies with velocity, or even how position varies with energy.

Another feature of the graph to note is that if you move your mouse around the actual graph area a little window appears in the lower left hand corner and gives you the coordinates that you are located at. Also look at the data points, and see that one of them is highlighted, and this corresponds to the frame of the video that you are currently paused at. Play the video and watch the highlighted point move right along in real time.

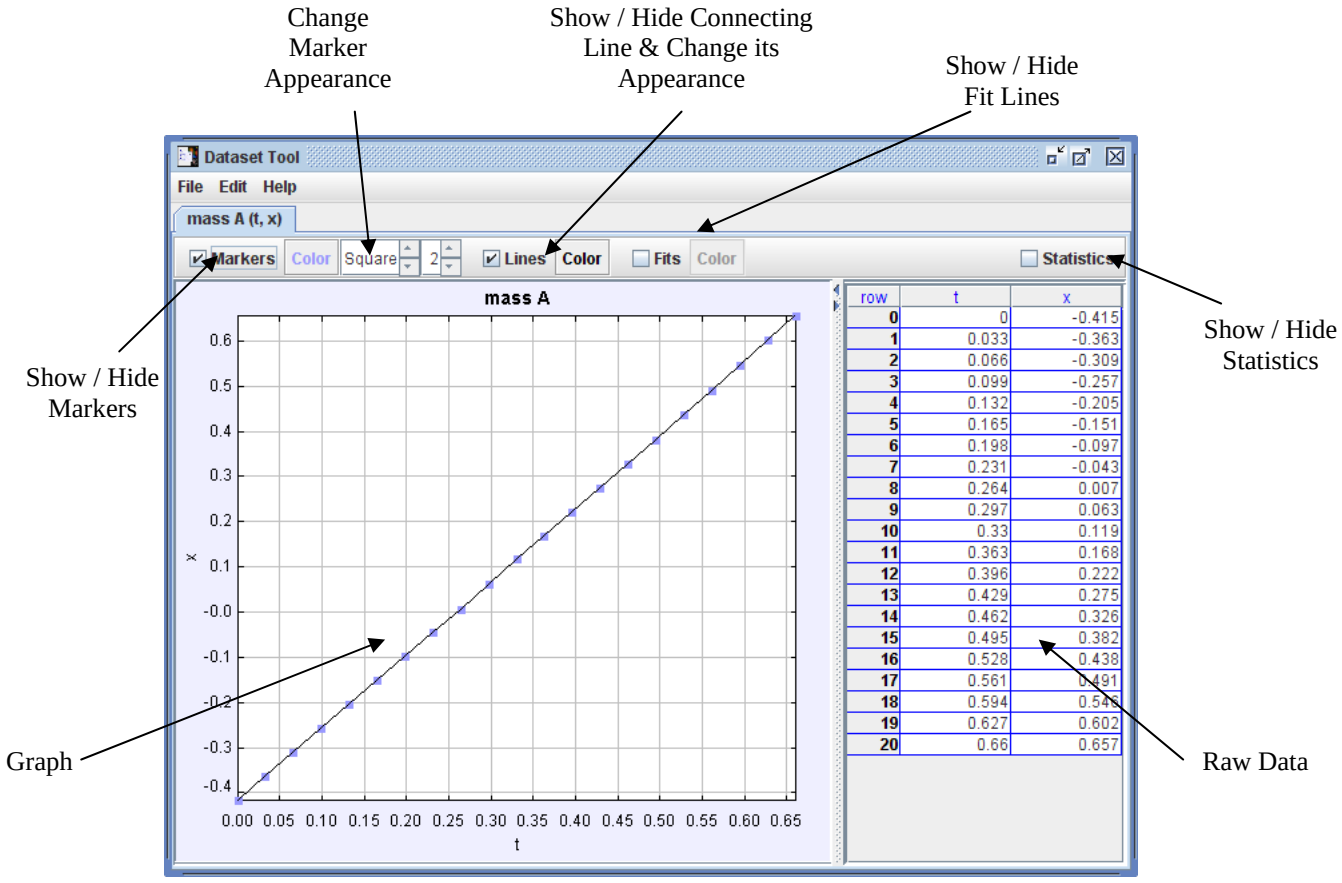
5....Analyzing Kinematic Variables

The fun with Tracker doesn't stop with just graphing your variables, Tracker can actually do calculations and give you numerical values for your variables as well. The first location you can do this is located with just viewing the values in a data table format, and this is located directly below the graphing window. If you don't see the data table window then you have it hidden (similarly to the graphing window from before) so look for a set of arrows pointing up / down below the graphing window to show or hide it.



This window works very similarly to the graphing window. Simply select which track you want to analyze from the track selection pull down menu, and select which values your viewing on the data table from the data selection button. This table window will give you any values you desire.

But that's not all! Go back to the graphing window and double click on the actual graph itself. You will be opened to the whole new world of Tracker data analysis. The window that opens should be similar to the one below:



This window has a HUGE amount of options to aid you in analyzing your data. Firstly, you can change the cosmetic look of the generated graph by adjusting if the markers (data points) are shown and what they look like, and if the connecting line is shown and what it looks like, by clicking near the top of the window.

If you click on the statistics option you will get a wide range of statistical information about your data, for example you mean, median, and deviation of your raw data.

A really powerful feature of the program is in its fitting tools for the data. You can click on the fits option to bring up another small window that allows you to fit a line, parabola, cubic, or any user defined function to your data. This is extremely powerful and useful for quick data analysis. (And of course, you can change the look of the fit line as well.)

One small note, to choose which variables you are analyzing, setup your graph in the base Tracker program first, then double click on it to be taken to this window. You can setup multiple graphs for analyzing at the same time and Tracker supports tabs in between then (see the tab for "mass A (x, t)" near the top of the window shown above).

For the ball toss video, try analyzing your data for a-y (acceleration in the y direction), see how close Tracker comes to giving you a mean value for the acceleration equal to gravity (9.8 m/s^2) that it should be.

Conclusion

Well, that should be more than enough to get you started using Tracker. This is actually not anywhere the entire list of features and you will discover many more as you play with the program. A quick list of things to try include…

- Create two masses that you track and then add a center of mass feature which will plot the center of mass between these two objects automatically.

- Track a vector quantity like a force by adding in a vector track instead of a point mass.

- Define your own kinematic variables for tracking, like potential energy, by defining the formula for the variable you want to analyze (in this case U = mgh, or U = m * 9.8 * y).

- View a scene from either the world frame, or the coordinate frame. See what happens when you view from a set of rotated axes.

Have fun with the program!