Details of the Throw

14.1 Observe and represent
Use the Logger Pro video “Ball Toss” to answer the following questions.
   a) Describe the motion on the way up and on the way down.
   b) Draw a vertical motion diagram for the motion on the way up
   c) Draw a vertical motion diagram for the motion on the way down.
   d) Are the changes in velocity arrows consistent?
   e) Describe another real life situation that is similar to an object being thrown up into the air.

Using Logger Pro
   1. Go to the start menu and click on “Programs”
   2. Select “Science” from the drop down list
   3. Select “Logger Pro” and click to open

Opening the file in Logger Pro
   1. At the top of the screen, click “File”, then “Open…”
   2. A dialog box will open. From the folder open, select “Sample Movies” and then open the folder “Ball Toss.” Select the embl file, and click “open.” Your movie should open up in a window.
   3. The video playback controls are in the lower left corner of the video window. From left to right the controls are: play, stop, rewind, to beginning, back 1 frame, forwards 1 frame

14.2 Observe and represent
You can find y vs. t data for the up and down motion of the center of a ball thrown upward in the video “Ball Toss” (the y-axis points up) using the following information:

Selecting your Data Points
Logger Pro can’t track objects automatically; it needs a human to tell it where an object is in each frame of the video.
   - Think about when you want to start placing data points (i.e. when you care about the motion? When do you not care?)
   - Think about where on the object you want to place the data points and why.
   1. Click the box in the lower right to open the video analysis sidebar. It looks like this.
   2. Click the second button from the top: “Add point” Now, using the video controls at the lower left of the video window, skip to the frame where you want to place your first point.
   3. Click on the video where you want to add your data point. A small dot should appear on the video where you clicked and the video should move to the next frame.
   4. Keep placing dots until you are finished taking data points. If you are unhappy with your choices (flip back through the movie to check the accuracy of your points) then you want go to the very top of the screen, click on “data”, and then choose “clear all data” from the list.
Making Graphs
1. You should now see that Logger Pro automatically has made an x-y graph. Reset the scales so the graph lies nicely in the middle by clicking on the numbers at the beginning and end of each scale. When you click each number, you can type in a new value. When you press enter, this value becomes the new endpoint of the graph.
2. To add a new graph, go to the top of the screen, click on “insert” and choose “graph.” Logger Pro will now insert a new graph.
3. The inserted graph will be some arbitrary scale. To change what is plotted on the two axes on this new graph, click on the axis label and select the variable you want to be measured on the horizontal and vertical axes.

Note: If you want to run the video and see how the graphs are correlated with it, select “Analyze” and “Replay” from the menu. When you select “Start” the movie will run and the graphs will appear in synchronization with the video.

Line Fitting
Logger Pro can try to tell us the equation of our graphs.
1. To fit a line to a section of a graph, select a graph and click and drag a box across the part of the graph you want to fit. A light blue shading will indicate which points will be fit. Then go to the top of the screen and click “Analyze”, and then choose “line fit…”
2. A new window will open with a picture of your graph and lots of “General Equations”. You can pick one of these general equations to try to fit your graph to by clicking in the circle in to the left of the equation and then clicking the “Try Fit” button at the bottom of the window. This will give you a preview of what the fit looks like compared to your graph. Try different fits and select the one that makes the most sense to you. When you’re done, click ok.
3. Now the fitted line and equation show up on your graph. Move the equation box around so that it does NOT COVER UP your graph.

Use the tools above to answer the following questions:
   a) Draw a position-versus-clock reading graph
   b) Draw a velocity-versus-clock reading graph. Find its slope. What do you call this slope?
   c) How does the slope on the position versus time graph relate to the points plotted on the velocity versus time graph?
   d) Use the velocity versus clock reading graph to determine the ball’s acceleration at the very top of its trajectory. Is the change in velocity consistent throughout the entire motion? On the way up? At the top? On the way down?
   e) What is the ball’s velocity at the top?
   f) Can you reconcile the answers to parts (d) and (e)? Explain.
   g) If the ball had zero acceleration and zero velocity at the top of its motion, what would happen to it?

Did you know?
The accepted value for the acceleration of objects close to Earth is 9.8 m/s², commonly referred to as "g". This was found experimentally in a manner close to the one you use in the problem above.

h) How does your value for the acceleration compare to the accepted value? What might have caused any discrepancies?

Adapted from A. Van Heuvelen and E. Etkina, *PUM Kinematics 2010*
14.3 Assumptions
You are jumping off a high dive into a pool of water. It took you 1.5 sec to hit the water.
   a) Draw a motion diagram for your motion while you are in the air, ending several seconds after you enter the water. Are the motions similar or different? Explain.
   b) If you were to find the velocity with which you hit the water with, what assumptions do you make about the motion as you hit the water?
   c) If you dropped a water balloon from the football stadium grandstands which takes 1.8 sec to hit the ground, what assumptions would you make about the final position and the objects motion?
   d) Discuss your answer with the class, are these valid assumptions, do they consider the motion of the object falling or the motion of the object sitting on the ground.

14.4 Reason and Represent
A ball is hit by a baseball bat which is 1.2 m above the ground, straight up at 24.0 m/s.
   a) Sketch the situation to the top of the path, be sure to label and list all important givens and unknowns. State your assumptions.
   b) Draw a motion diagram and describe what happens to the speed as the ball approaches its maximum height.
   c) Determine all possible unknowns for the object when it reaches maximum height.

14.5 Regular Problem
The fuel in a bottle rocket burns for 2.0 s. While burning, the rocket moves upward with an acceleration of 30 m/s².
   a) What is the vertical distance that the rocket travels while the fuel is still burning, and how fast is it traveling at the end of the burn?
   b) After the fuel stops burning, the rocket continues upward but is now slowing at a rate of about 10 m/s². Estimate the maximum height that the rocket reaches. What assumptions have you made in working through this problem?
14.6 Regular Problem
A ball is thrown upward at 20 m/s from the top of a 150 m building.
   a) Determine all the information about the ball when it is at a height of 165 m.
   b) Determine all the information about the object when the ball just hits the ground.

14.7 Regular Problem
James went outside and said he could throw a ball 25 meters upward. The ball takes 5.2 seconds to hit the ground.
Show that James could throw at least 25 m up. Discuss any assumptions you made to determine this answer.

14.8 Reason
Examine the graph below.

14.9 Reason
You hold two identical golf balls. You drop one ball and simultaneously throw down the other ball. Explain what will be the same and different about their motion.
   a) Represent the motion of the balls with two motion diagrams next to each other.
   b) Draw velocity versus time graphs for the two balls using the same axes.
   c) Draw position versus time graphs using the same axes.

Adapted from A. Van Heuvelen and E. Etkina, *PUM Kinematics 2010*