2016

Yoyo Lab (In-lab)

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Date: _____

Yoyo Lab

In-lab instructions and student notes

Name: __________________

The big question(s)

- How can you figure out the moment of inertia of an unwinding spool from a video?
- Is the value the same as what you could calculate by using just a ruler and a scale?

Procedure

1. Make the video of the motion using Vernier's Video Physics app on the iPad. Some suggestions for making video that's easy to analyze follow. Make sure that
    - the yoyo shows up well against the background
    - the iPad camera is stationary
    - the iPad is held parallel to the yoyo (You may need to prevent the yoyo from twisting as it descends)
    - the yoyo's motion fills a majority of the screen (use iPad in landscape orientation)
    - there is a dot on the edge of the yoyo so you can count rotations as the yoyo unwinds
    - you release the yoyo after you begin recording
2. Open up Video Physics and view your video. Check to make sure it's good enough for analysis. Is the object clear (not blurry)? Is the center of the yoyo clearly visible in most frames? Is the mark on the yoyo you made to count rotations clearly visible? Did the yoyo remain parallel to the iPad as it descended? Is the yoyo's descent is mostly vertical and in a straight line? (Depending on how release the yoyo, it might wobble around some- that's bad). If your video isn't good, now's the time to reshoot it.
3. Once you think your video is good enough, it's time to track/mark the motion of the object using Video Physics. The object you will mark/track is the center of the yoyo. ***Strategic data collection is key for this lab****- Video Physics has no way to track the orientation of the yoyo.* Here are some recommendations:
    a) Track/mark the center a few frames before the yoyo is released. On paper (or in your brain), note the location of the dot at the edge (so you can count rotations).
    b) Track/mark the first few frames at the beginning of the motion. After that, only mark the location of the yoyo's center when the edge dot passes its original orientation. (This is to make it easy to count how many complete rotations has made just by looking at your graph).
4. Use the software to mark the length of your reference object. Use the radius of the yoyo's body as your reference object. Measure the radius with a meter stick. Use the software to enter this information.

radius of yoyo = _______________ (don't forget units)

5. Adjust the axes so that the motion of the object is along the y-axis. Check your graphs in Video Physics to make sure that x-velocity and x-acceleration are both zero throughout the motion. (If not, adjust your axes slightly and recheck).

6. Check the quality of the graphs. Do the graphs show a consistent trend? Is there enough data in all parts of the graph? If not, now's the time to add those data points (if you skipped them during the tracking process).
7. Measure the mass of the spool and record it here:

mass of yoyo = ________________ (don't forget units)

8. If you think the data is good enough, it's time to analyze the data using Graphical Analysis on the iPad. (To export the data to GA from VP, click the share icon at upper right, choose "data file", "open in…" and "copy to Graphical Analysis")
9. In previous iPad labs, you used the "fitting" tools. You clicked-dragged to select a section of a graph you wanted to fit and interpreted the fit equation. In this lab, this won't be very helpful. You will more often want information about individual data points. Instead of click-dragging, simply click on the point you want to know about. You will also find it useful to change the appearance of the graph from "line" to "points."
10. The main data you want to get off the video is

Δy	the distance the yoyo descended from where it was released
v	The speed of the yoyo has once it has descended a distance Δy
N	The number of rotations the yoyo made as it descended Δy

Use a data point near the end of the video as your "final" moment and a data point just before release as the "initial" moment. Record the data below, along with a short description* of how you used the software to determine each: (*Which graph did you consult? Which data point(s)?)

Quantity	Value (w/ units!)	Short description of how you found the value
Δy		
v		
N		

11. Use the data to calculate the radius of the yoyo's axle. Show your work. Check to make sure your answer is reasonable (i.e. matches what you can "eyeball").

Use video data to calculate radius of yoyo's axle: (Show your work)

12. Use the data to calculate the moment of inertia of the yoyo. Show your work.

Use video data to calculate yoyo's moment of inertia: (Show your work)

13. It is also possible to calculate the moment of inertia of the yoyo *without the video* if you know its dimensions and mass. Use the space below to calculate the moment of inertia, based only on its dimensions. (Hint: Ignore the inner axle- it contributes almost nothing to the overall moment of inertia of the yoyo).

Calculate yoyo's moment of inertia without using video data: (Show your work)

14. The yoyo's axle has a mass of roughly 10 grams and a radius of roughly 1 cm. Calculate its moment of inertia, based on these dimensions.

Calculate moment of inertia of yoyo's axle: (Show your work) What fraction of the yoyo's overall moment of inertia is due to the axle? Based on your answer, comment on the effect of ignoring the axle's contribution to the overall moment of inertia.

15. You measured the moment of inertia of the yoyo in two different ways: using video and from its dimensions. Record the results below:

Based on video data: $I_{yoyo} =$

Based on dimensions: $I_{yoyo} =$

Are these values for I_{yoyo} similar? (Calculate a % difference before answering this question).

Should the two values of I_{yoyo} be similar? Why or why not?