Physics 201

Fall 2009

Two Dimensional Motion – Due Friday November 6, 2009

Points: 30

Name__________________

Partners________________________

This is a more detailed lab experiment than the exercises you have done in the class in the past. You will work in groups of three as usual but the role of each person in the experiment must be well defined. You may choose to rotate roles or play the same role throughout the project. Each member of the team will write a unique and separate report. You should describe your role in the experiment clearly in the report.

Some of the equipment will be set up in Room 109 (across the hallway)

The theme of the lab is "two-dimensional motion". To keep matters simple, I would confine the topics to free fall. Here are some topics that would be suitable:

- **Throwing a tennis ball in the air (Room 117)**

  Shoot a movie as one of your partners throws a tennis ball to the other partner. Then analyze the data frame by frame and find the x and y coordinates of the ball as it moves from one hand to another. You will be required to draw the following graphs:

1) The x component of the velocity v_x vs. time.
2) The y component of the velocity v_y vs. time.
3) The y coordinate vs. the x coordinate.
4) Find the acceleration due to gravity from one of the above graphs (which one?) and compare it to the standard value (% uncertainty).

- **The "dropper shooter" experiment (only one set-up available in SC 109) – shoot the movie to analyze the motion of both the balls – the dropping ball and the ball that is shot out of the "gun".**

1) Plot a graph of v_x vs. time for the ball that is shot out and graphs of v_y vs. time for both the balls.
2) Use this to find the acceleration a_y for *both* balls – compare it with the acceleration due to gravity 'g' (percentage uncertainty).
3) Compare the motion of both the balls – why do they land at the same time?

- **The train-shooter experiment (only one set up available in SC 109)**

1) Shoot a movie of the train shooting the golf ball in the air. Plot of a graph of v_x for both the train and the golf ball. Plot a graph of v_y vs. time for the golf ball and find the acceleration in the y direction. Compare it to ‘g’.

2) Why does the golf ball always land in the “carriage”?

- **Throwing a ball vertically down and recording it bouncing off the floor vertically (Room 117).**

1) Predict the rebound height assuming no air resistance using the initial velocity and release point.
2) Compare it to the actual rebound height – why are these numbers different?
3) What is the time interval when the ball is moving upward and the time interval when it is moving downward between bounces? Do these match what you would expect from the kinematic equations?
4) Plot v_y vs. t and y vs. t.
5) Calculate the acceleration due to gravity. Compare with $9.80 m/s^2$ and report the percentage uncertainty.

- **Throwing a ball with a horizontal velocity and recording the bounces (Room 117).**

    1) Predict the rebound height assuming no air resistance using the initial velocity and release point.
    2) Compare it to the actual rebound height – why are these numbers different?
    3) What is the time interval when the ball is moving upward and the time interval when it is moving downward between bounces? Do these match what you would expect from the kinematic equations?
    4) Plot v_x vs. t and v_y vs. t.
    5) Calculate the acceleration due to gravity. Compare with $9.80 m/s^2$ and report the percentage uncertainty.

Instructions to shoot the movie:

You could shoot the movie in the hallway first, rewind it to the right spot and then bring it in to analyze the video.

- Log in to the computer.

- Prepare your shot – are the actors in place? What is your plan of action? What is your length scale? The movie will work best if you are at least 4m away (farther the better – it will reduce parallax error). Tape the meter stick in a vertical position in the field view so that it forms your background. Make sure it is on the same plane as the plane of motion of your ball. Use a racquet ball if you are using the whiteboard as your background, use a tennis ball for a darker background.

- Make sure the camera is plugged in, turned on in 'camera' mode. Can you see an image on the camera screen?

- Plug firewire in to camera and computer.

- You will see the "Digital Video Device" box open. Click "Ok" to start video capture.

- Enter name for your video file on the top line in the "captured video file" box. Click "Browse" next to the second line and select "Desktop" and click "ok", then click "next" on the "captured video file" box.

- Select "Digital Video Format (DV-AVI)" and click "next".

- Prepare for the shot. When you are ready, click "start capture". When shot is finished, click "stop capture". Do not leave capture running! When you have a good video, click "Finish".

- The movie frame will appear in the upper left hand portion of the screen. Click and drag it down to the empty white box at the lower left portion of the screen.

- If you know how to edit with Movie Maker, you can shorten the video at this point to keep only the essential frames. This is not necessary – it just reduces the number of frames. If you are not accustomed to editing with Movie Maker, go to the next step.

- Click on "Finish Movie" at left, then "save to my computer". Give the video a new name and save it to the desktop.

- A box titled "Save Movie Wizard" will open – click on "other settings" , then select "DV-AVI (NTSC) and click "Next".

- Minimize Movie Maker.

- Open Logger Pro 3.4.5. The default file will open up.

- Pull down the "Insert" menu and click on "movie". Select your movie from the desktop and click "ok".

- Click on the button at the bottom right (the one with the parabola of red dots). This will open a toolbar on the right. Click on the horizontal meter stick icon. Now you are ready to define the length scale in your movie. Position the cursor very carefully on one end of the meter stick and drag it to the other end of the meter stick. This opens up a pop-up menu confirming that this length is 1.0m. Press yes.

- Press play on the movie. Once the movie ends, you can move the slider back and forth to choose your starting frame (just after the ball leaves your hand). Pause it on this frame.

- Click on the red ball cursor (red dot in the middle of the crosshair) in the toolbar and move the cursor to the center of the ball and click. This should leave a red dot at this point and advance to the next frame.

- Repeat to the end of the motion. Make sure that the ball is falling freely in all the frames.

- As you click on the frames, the table and graphs showing x and y positions vs. time will appear on the screen.

- If you are tracking two balls, to track the second ball, click on the icon that shows red and green balls. This will pull down a tiny menu. Click on "add point series" and then click on the other ball that you want to track.

  You will need to do this for the dropper-shooter and the train shooter experiments.

- **To plot graphs of v_x and v_y:**
  Select the graphs of x and y positions vs. time by left-clicking on the graph. Pull down the "edit" menu and select "copy" and then "paste" to make a copy of the graphs. Separate the two graphs.

  Right-click on either graph and select "graph options". Deselect 'x' and 'y' and select 'x –velocity' and 'y-velocity' instead. Click "done".

  You can follow the above process to plot any of your measured values on the graph vs. time.

Analysis and Results:

- Report your data in the form of a table – this should be easy if you press “insert table” after selecting the appropriate graph – you may print and attach your data table to your report. Remember the more the data, the better your accuracy. You may have to repeat your experiment more than once.
- Draw the graphs required (you can use Excel or graphical analysis) and calculate the relevant physical quantities.
- Answer all the questions.
- Report your result with the experimental error.

Report:

The report should be type-written and should consist of the following parts:

- Objective: Define your hypothesis here.

- Description of the experimental setup including a diagram or a picture (neatly drawn not sketched roughly).
- A short passage describing the procedure – how did you “set the stage” for your movie and the process used to shoot the movie – include the setbacks you had while doing the experiment (if any). This is also where you would describe your own role in the project.
- Data Table
- Analysis of the data – note the relevant equations and show a sample calculation.
- Results: If you were measuring something, this should be reported here along with a comparison with the theoretical value.
- Conclusion: what did you learn from the experiment? What might have been the sources of error? What would you do differently next time? What other experiments would you like to do in the future related to this one?