Lab 1. One-dimensional Motion

Lab Report

1. Considering the traffic of a typical automobile on EN 16th, do you think the motion is constant or changing? Do you think the motion of a typical auto on EN 16th complies with the speed limit? Briefly propose a way to test your answers to these questions. Describe how you could present the information you gather in a way that someone outside this class would find persuasive.

2. What did you choose as the origin for your object's position? Describe how you measure and "calibrate" the positions or times for your object?

3. Briefly explain how you determined what time value to associate with the velocity calculated over a given time interval.

4. Is your object in a state of constant or changing motion? What sources of *systematic* error do you think might exist? Are any of them relevant to your analysis? ***In all questions, use your data and the results of your analysis to justify your interpretation***. This will be graded and comprise a major portion of your Lab 1 score.

Lab 2. One-dimensional Acceleration

Lab Report

1. Write out the equations describing the position, velocity, and acceleration vs. time for an object in free-fall. Indicate the physical quantities corresponding to the slope and intercept.

2. Briefly describe your experimental setup, including the object you selected and how you carried out your measurements. Sketch a simple diagram of your setup.

3. Provide the value and estimated uncertainty for the free-fall acceleration derived from your results in Part B.

$$g = \_\_\_\_\_ \pm \_\_\_\_\_$$

4. Interpret your results! For example, address such questions as the following: In what ways do the data show the equations from question 1 to be valid for your data? In what ways do the data show these not to be valid for your data? Is your measured value of the free-fall acceleration consistent with your expectation? Do the results of your analysis indicate the existence of systematic errors? How so? What sources of *systematic* error do you think have the largest effect? ***In all questions, use your data and the results of your analysis to justify your interpretation***. This will be graded and comprise a major portion of your lab score.

Lab 3. Momentum

Lab Report

1. Briefly discuss the method you devised to test momentum conservation. Describe your experimental setup, including the objects you selected, how you induced your collisions, and how you carried out your measurements for velocity. Sketch a simple diagram of your setup.

2. Write out a linear form of the equation relating the change in velocity of the two objects. From this equation, indicate the physical quantities corresponding to the slope and intercept of your linear regression.

3. Record the slope, intercept, and R^2 from your linear regression.

$$\text{slope} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$\text{intercept} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$R^2 = \_\_\_\_\_$$

4. Interpret your results! In what ways are the data consistent with your hypothesis? In what ways are they inconsistent? Do the extracted values for your slope and intercept make sense *quantitatively*? What sources of *systematic* uncertainty could be affecting your experiment? ***In all questions, use your data and your analysis to justify your interpretation***.

Lab 4. Galilean Relativity

Lab Report

1. Briefly discuss the method devised to make observations from two different inertial reference frames. Describe the setup, the accelerating object, the 8 "events" measured from the two different frames, and how you carried out the measurements. Sketch a diagram of your setup.

2. How does the *qualitative* behavior of the graphs change as you move from the "Earth" frame to the other? In light of what you expect from Galilean relativity, does this behavior make sense? Why or why not?

3. Record the two values you get from Part B for the relative velocity of the two frames.

$$v_{AB1} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$v_{AB2} = \_\_\_\_\_ \pm \_\_\_\_\_$$

Quantitatively argue why the two values are consistent or inconsistent. Quantitatively argue how your data are consistent or inconsistent with what you expect from Galilean relativity. Discuss the presence of any systematic uncertainties or argue why you conclude your results are free of them. Remember to back up your conclusions with a quantitative measure.

Lab 5. Interactions and Potential Energy

Lab Report

1. Briefly discuss the method devised to place an object into vertical free-fall using an elastic process. Include a brief description of your calibration. Sketch a diagram of your setup.

2. What value do you expect for n in Eq. 5-2? What led you to this conclusion?

3. Briefly give a qualitative discussion of your U vs. Δl plot.

4. Write out the mathematical expression for $\log(U)$ vs. $\log(\Delta l)$ and label the "slope" and "intercept" for the linear regression.

5. Record your empirical value for n

$$n = \_\_\_\_\_ \pm \_\_\_\_\_$$

Quantitatively argue how your data are consistent or inconsistent with expectation. Discuss the presence of any systematic uncertainties. Back up your conclusions quantitatively.

Lab 6. Forces and Equilibrium

Lab Report

1. Record the measured spring constant values for your individual springs

$$k_1 = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$k_2 = \_\_\_\_\_ \pm \_\_\_\_\_$$

2. Briefly discuss how you plotted your spring-pair data to achieve a linear relationship between the applied force and the stretch length and record the measured "effective" spring constants.

$$k_{\text{parallel}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$k_{\text{series}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

3. In what ways are your data consistent or inconsistent with your expectation based upon Hooke's law? Cite specific quantities from your data analysis to justify your claims.

4. Do your measured "effective" spring constants make sense, given your measured individual spring constants? As a part of your discussion, cite "theoretical" values for the effective spring constants, using your measured individual constants and calculations based upon Hooke's law and your understanding of spring systems at equilibrium.

Lab 7. Forces and 2-D Motion

Lab Report

1. Briefly describe your method to determine the punch force and record your estimate

$$F = \_\_\_\_\_ \pm \_\_\_\_\_$$

2. Briefly describe how you predicted the horizontal distances traveled from the "stationary" and "moving" (relative to Earth) reference frames and record the estimates

$$\Delta x_{\text{stationary}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$v_{\text{moving}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$\Delta x_{\text{moving}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

3. Record the horizontal distances traveled for the object in the "stationary" and "moving" (relative to Earth) reference frames.

$$\Delta x_{\text{stationary}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$\Delta x_{\text{moving}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

4. In what ways are your data consistent or inconsistent with your expectation? What systematic uncertainties may exist? Are any relevant, and if so which do you think are most relevant? Cite specific quantities from your data analysis to justify your claims.

Lab 8. Angular Momentum

Lab Report

1. Briefly describe your setup, including the rotating apparatus, the projectile you chose, and how you bring them into inelastic collision. Draw a sketch, as well.

2. Record the linear regression information from your analysis of ω vs. v

$$\text{Slope} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$\text{Intercept} = \_\_\_\_\_ \pm \_\_\_\_\_$$

$$R^2 = \_\_\_\_\_$$

3. Interpret your results! Are your results consistent with what you expect, based upon Eq. 8-4? Do the results of your analyses indicate the existence of systematic uncertainties? How so? What sources do you think have the largest effect?

Lab 9. Rotational Inertia

Lab Report

1. Record the estimated rotational inertia of your object and briefly describe the method used

$$I_{\mathrm{A}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

2. Record the rotational inertia measured using the principles of rotational kinematics. Briefly describe the experiment and include the relevant rotational kinematic equations. Also, describe the method used to analyze the data, e.g. an average of several calculated values or a linear regression. If you use a linear regression, give the linearized form of your equation and indicate which quantities represent the slope and intercept.

$$I_{\mathrm{B}} = \_\_\_\_\_ \pm \_\_\_\_\_$$

3. Interpret your results! Are I_{A} and I_{B} consistent? Does your analyses indicate the existence of systematic uncertainties? How so? What sources do you think have the largest effect?

Lab 10. Torque

Lab Report

1. Briefly describe your setup, including the object you chose to balance, the pivot, and the weights you chose. Draw a sketch of your setup.

2. Cite the relationship you worked out to relate the mass of the object, the mass of the weights, and the lever arms. If you use a linear regression for your analysis, label the quantities representing the x-values, y-values, slope, and intercept.

3. Record the mass of the object determined by your experiment and its uncertainty, along with the mass measured directly, e.g. on a scale.

   $m_{\text{exp}} =$ _____ $\pm$ _____

   $m_{\text{direct}} =$ _____ $\pm$ _____

   Interpret your results! Are the mass values consistent? Are your data consistent with what you expect from rotational equilibrium? Are systematic uncertainties relevant for your analysis? What sources do you think have the largest effect?