Lab: The Motion of Rolling Objects — AP Physics

Background

Objects that roll without slipping down an inclined plane can be analyzed using Force/Torque concepts, or using Energy (translational and rotational) concepts. In this extended lab, you'll be using both approaches to predict the theoretical motion of a hoop, a disk, and a sphere as they roll down an inclined plane. You'll then collect experimental data to verify or refute your predictions.

Objective

To theoretically predict the motion of a hoop, a disk, and a sphere down an inclined plane, and to verify your predictions by experiment.

Equipment

To be determined and described by you

Procedure

Part I. Theoretical Development

Using first Force/Torque concepts and then Energy (translational and rotational) concepts, develop equations that yield **position**, **velocity**, and **acceleration** as a function of **time** for three different objects rolling down an inclined plane: a hoop, a disk, and a sphere. It won't be surprising to find that at least two other variables—angle of incline θ and acceleration due to gravity **g**—appear in your equations. Perhaps mass m and radius R of the objects will be a factor as well?

Likewise, it shouldn't be surprising to find that the two different approaches yield identical equations. For this reason, in your write-up you'll need to be extremely clear in showing your *development* in both approaches.

Part II. Experimental Confirmation

Perform experiments and collect data that will allow you to verify or refute your theoretical predictions. Again, because each group will be performing experiments of their own design, you'll need to be *extremely clear* in describing your experimental set-up and procedure. Lists of equipment used, data tables of data collected, and photos or diagrams of your set-up should all be part of the laboratory documentation.

Part III. Reporting Results

You will be preparing a hand-written report as your lab write-up (see further details below). Your results should be reported both as data tables and as a series of three graphs—one for each type of object rolled down the incline—with two lines on each: one predicted by your calculations, and one of your experimental results. These graphs should include the functions that are being displayed in the body of the graph itself—your predicted equation and the best-fit model of your collected data—and (obviously) include labels and units on x– and y–axes, as well as a title.

You'll also want to report the percent error between your predicted acceleration and your measured acceleration, which is easily determined from a regression of your data's trendline.

We expect that our experimental data will vary somewhat from our theoretical predictions. Is there a systematic variance between the two? How much error or uncertainty will be acceptable to you in this lab? Do you have reasonable explanations for any error?

Questions

As listed above.

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Additional Notes

It's expected that your experimental data will consist of position-time data collected in class. By entering this data into a spreadsheet program, you can:

1. present your data in table form
2. create an *x-y* scatterplot of your data
3. identify a regression that models your data numerically

Instructions on how to use spreadsheet software to accomplish these tasks is available from the instructor.

The report for this lab experience will include:

- **Text**
  Write legibly using blue ink, black ink, or dark pencil. Other colors may be used as needed in diagrams, for highlighting, etc.
- **Graphics**
  Graphical images are necessary for free-body diagrams. Include labels as appropriate.
- **Equations**
  Used for mathematical derivations, calculations.
- **Data Tables**
  These are presented in table or spreadsheet form, with relevant data only.
- **Graphs**
  Each graph should be a minimum half-page per graph, and generated by computer based on spreadsheet analysis, Python program, Desmos software, etc. Please include regression formula for your data on graph.

Your final report will likely run 7-15 pages with cover page, and will be submitted in paper form (stapled), on engineering computation paper and printouts of graphs, and photos, if included.