# PHYS 2211L - Principles of Physics I Laboratory

# Laboratory Advanced Sheets
# Rolling Motion

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**Objective**. The objective of this laboratory is to study the rolling motion without slipping and compare the moments of inertia of the solid and hollow spheres and cylinders.

**Theory**.

Rolling is an important example of motion of a rigid body in which translational motion of the center of mass of the body is combined with rotational motion about the axis passing through the center of mass of the body. While analyzing the motion, the translational and rotational motions can be treated separately. An important case of such motion is **rolling without slipping**, in which the instantaneous velocity of all the points of contact of the rolling object with the surface is zero. It can be shown that rolling without slipping requires the following condition:

$$v_{cm} = R\omega$$

where $v_{cm}$ is the speed of the center of mass of the rolling body,

R is the radius of the body, and

$\omega$ is the angular velocity of the rotation.

For a rigid body rolling without slipping down the slope which makes an angle $\theta$ with the horizontal, simple analysis shows that the acceleration of the center of mass of the body along the slope can be expressed as

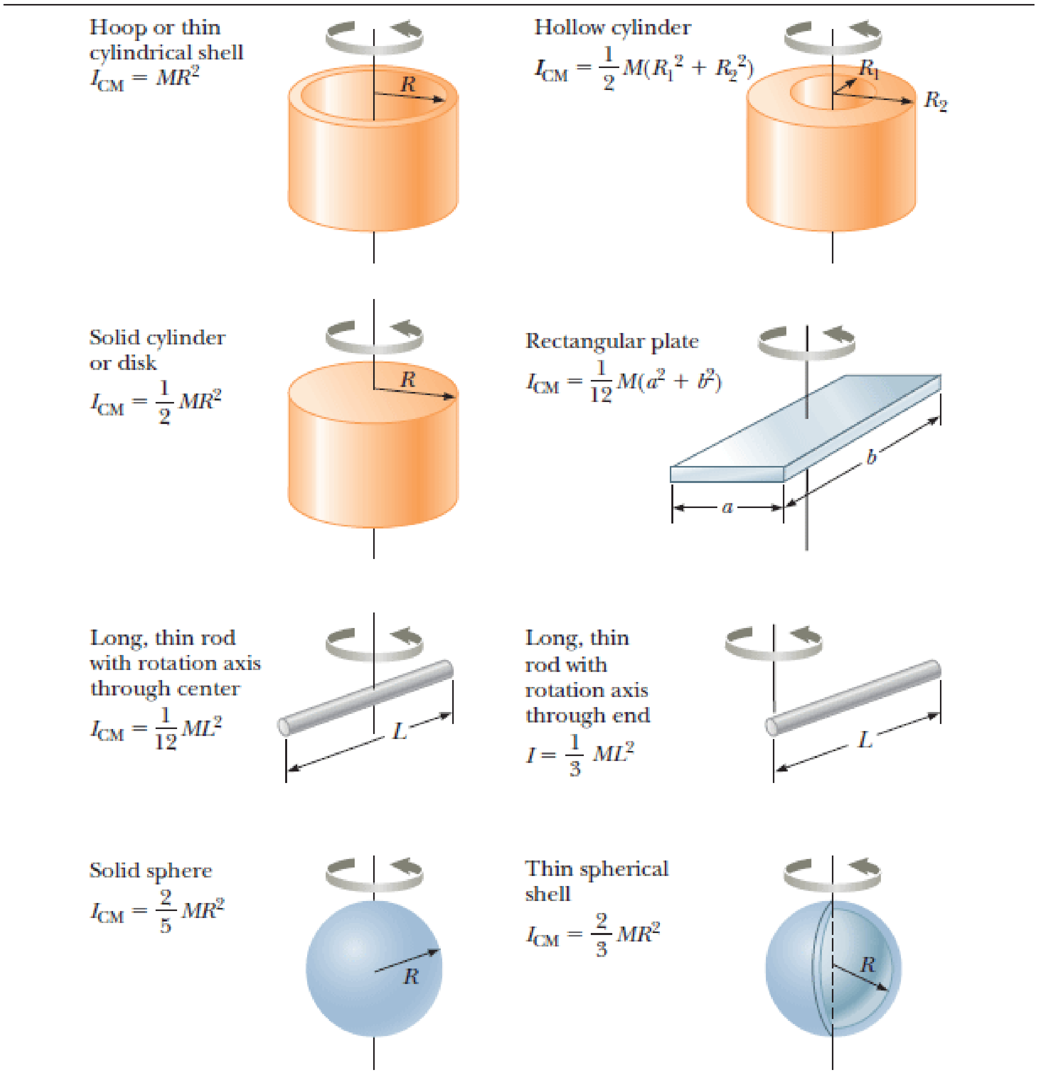
$$a_{cm} = \frac{g\ sin\theta}{1+k}$$

Where $g$ is the acceleration due to gravity, and

$k$ is the numerical coefficient in the moment of inertia of a rigid body which depends on the geometrical shape of the body.

The moments of inertia of some common homogeneous rigid objects are listed in the table below.

*Moments of Inertia of Homogeneous Rigid Objects with Different Geometries*




**Apparatus and experimental procedures**.

- Equipment.
  1. An incline.
  2. Solid and/or hollow cylinders, solid of hollow spheres (2).
  3. Meter stick/ruler.
  4. Camera.
  5. Computer with the Tracker software.

- Experimental setup. The experimental setup is shown in Figure 1 (provided by the student).
- Capabilities. To be provided by the student.

. **Requirements**.

- In the laboratory.
    1. Take a video of solid and/or hollow sphere rolling down the slope.
    2. Take a video of solid and/or hollow cylinder rolling down the slope.
- After the laboratory. Complete the following portions of the laboratory report.

**Para. 3. Apparatus and experimental procedures**.

1. Provide a figure showing the experimental setup.
2. Provide a description of the capabilities of the equipment used in the experiment.

**Para. 4. Data**.

1. Provide a video of your experiment.
2. Provide a copy of your spreadsheet with calculations. Include the following:
    A. Measured angle of the incline.
    B. The Tracker data for the solid/hollow sphere and solid/hollow cylinder.
    C. Graphs of the *x*- coordinates of both objects as a function of time with the quadratic regression included on the chart with the corresponding equation and the $R^2$-value.
    D. Calculation of the experimental and theoretical acceleration of both objects along the incline.
    E. Calculation of ratio of the experimental and theoretical accelerations of two objects.
    F. Calculation of the Percent Discrepancy for the ratio of the experimental and theoretical accelerations.

**Para. 5. Results and Conclusions.**

1. Provide a summary of the experimental and theoretical accelerations for all objects studied.
2. Provide a statement on the accuracy and precision of your experiment.
3. Describe sources of systematic error in the experiment.
4. Describe sources of random error in the experiment.