THE 09 – Analysis of motion of a symmetrical rolling object

[Answer ALL inquiry questions (THE-IQ) as you read through the experimental tutorial]

SECTION 01 - Background and preparation for the experiment

Consider a symmetrical object rolling about its axis of rotation along an incline plane, see Fig. 01. Notice that the object rolls due to friction between the object and the plane. Both its inertia and the rotational inertia determines its eventual motion. In this experiment you will analyze both the translational and rotational motion of the object by applying the Newton's laws of motion.

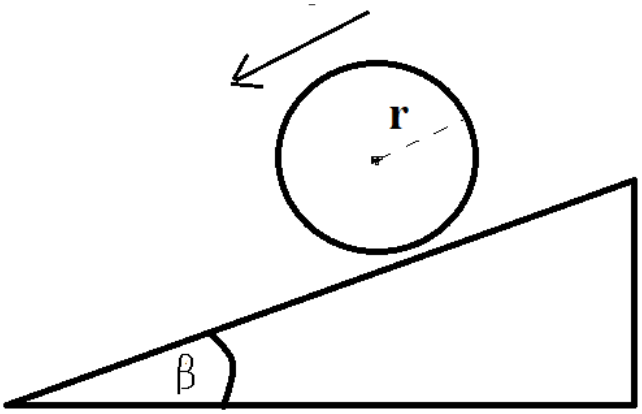

Fig 01. A symmetrical object moving along an inclined plane

THE-IQ 09-01

If the mass of the object is m, the frictional force along the plane is f_k and the acceleration of the object along the plane downwards is a, which equation best describes the translational motion of the object along the inclined plane?

A) $mg\,Sin\beta - f_k = ma$ B) $mg\,Sin\beta + f_k = ma$ C) $mg\,Sin\beta - f_k = 0$ D) other

THE-IQ 09-02

For the above condition, after considering rotational motion of the object, which equation is most accurate? Let the moment of inertia of the object be I.

. A) $f_k\, r = I\, a$ B) $f_k = m\, r\, a$ C) $f_k = 2\, m\, r\, a$ D) none

SECTION 02- TAKE-HOME EXPERIMENT

Things you will need:

An inclined plane, Object symmetrical about the axis of rotation, Measuring tape, Protractor, Phone with a camera/ video, Tracker software

Experiment

1. Analyze the equations you wrote down, see if you can estimate the coefficient of kinetic friction, μ_k by measuring the acceleration of the object and the angle of inclination.
2. Identify suitable independent and dependent variables based on the analytical expression you derived.
3. Estimate the coefficient of kinetic friction using a graphical method.
4. Further analyze the equations you wrote down, see if you can estimate the moment of inertia, I as a multiple of mr^2
5. Compare your estimate in part 4 with the theoretically predicted.
6. Feel free to use the Tracker software to measures physical parameters.

Analysis

1. Estimate the coefficient of kinetic friction, μ_k and the moment of inertia, I as a multiple of mr^2 using a graphical method. You will have to fit a suitable mathematical model to your data (suitable regression) to gather the necessary parameters.
2. See if conservation of mechanical energy is applicable to your system, if NOT think about the reasons.

THE-IQ 09-03

What assumptions did you make during the experiment?

THE-IQ 09-04

What are the possible reasons if your experimental results predict non-conservation of mechanical energy for this system?

Reporting

1. Write the experimental methodology in your own words.
2. Prepare a figure panel that highlight important findings.
3. Write an abstract (< 250 words)

Upload all three (3) above in a single document using the link provided in the LMS.