MECE08009 Dynamics 2

Inertia Lab Report Proforma

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Experiment:	Inertia Lab	**Date**:	2023/03/16

Conclusions: List your conclusions as a series of brief, numbered statements. Refer to the supporting document *Writing Conclusions* for guidance. Do not exceed 150 words for the conclusions.

1. The experimental results for the moment of inertia did not correspond particularly well to the theoretical value, with percentage errors between 10% and 30%. The trifilar pendulum was particularly bad, with calculated error in excess of 10% and a 30% deviation from the theoretical value.
2. The theoretical moment of inertia was 0.0175±0.0001 kg-m^2. Both experimental methods of determining the mass moment of inertia produced significantly lower numbers than expected. This was unexpected; the sources of experimental error discussed below should tend to increase rather than decrease the measured moment of inertia.
3. The slope experiment is more accurate and more precise than the pendulum experiment.

Results and Error Analysis: State the formal error expressions and your calculations for each of the calculation methods (based on equations 2, 9 and 10).

The theoretical calculation for inertia of the disc is

$$I = \frac{1}{2} m r^2$$

with relative error

$$\frac{\delta I}{I} = \frac{\delta m}{m} + \frac{2\delta r}{r}$$

For a disc rolling down a slope, the inertia is

$$I_{slope} = m r_0^2 \left(\frac{g h t^2}{2 s^2} - 1 \right)$$

with relative error:

$$\frac{\delta I_{slope}}{I_{slope}} = \frac{\delta m}{m} + \frac{2\delta r_0}{r_0} + \frac{\delta g (h t^2)}{g h t^2 - 2 s^2} + \frac{\delta h (g t^2)}{g h t^2 - 2 s^2} + \frac{2\delta t (g h t)}{g h t^2 - 2 s^2} + \frac{\delta s (2 g h t^2)}{s(-g h t^2 + 2 s^2)}$$

For an object on a trifilar pendulum, the inertia is

$$I_{pend} = \frac{g m R^2 \tau^2}{4 \pi^2 L}$$

with relative error

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$$\frac{\delta I_{pend}}{I_{pend}} = \frac{\delta g}{g} + \frac{\delta m}{m} + \frac{2\delta\tau}{\tau} + \frac{2\delta R}{R} - \frac{\delta L}{L}$$

The error in repeated measurements was found by taking the standard deviation of the measurement set and dividing by the square root of the number of measurements to get the standard deviation of the mean.

The error measurements estimated from the accuracy of the measuring instruments and from the standard deviations of the repeated measurements were propagated forwards through the error formulas and the results tabulated in table 1. The Percent Error column lists the percentage deviation from the theoretical result.

Inertial Measurement	Value [kg m^2]	Absolute Error [kg m^2]	Relative Error [-]	Percent Error [-]
I (theoretical)	0.0175	7.49E-05	4.28E-03 = 0.43%	
I_{slope}	0.0158	3.38E-04	2.14E-02 = 2.14%	-9.81%
I_{pend}	0.0123	1.54E-03	1.26E-01 = 12.6%	-30%

Table 1: Experimental Results

Discussion: Give a critical appraisal of your findings. Mention relevant observations, assumptions and weaknesses of your work, of the lab experiment etc; or questions asked throughout the lab worksheet could provide some useful prompts, but you are not confined to these. Do not exceed 300 words.

1. There are many potential sources of experimental error in determining the mass moment of inertia. However, most of these would tend to increase rather than decrease the effective moment:
    a. Air resistance may increase the effective mass of the disc, thereby increasing the time it takes to roll down the slope and the period of the pendulum swing. This effect will be particularly pronounced for geometries that are designed to move air, like turbines or fans. (This effect is not expected to be particularly pronounced for this experiment, as the experimental geometries were all smooth and thus unlikely to move large amounts of air as they spun, but a fluted geometry would show higher measured moments of inertia than expected.)
    b. Friction and energy dissipation (from e.g. hysteresis in the slope and pendulum lines) should increase the rolling dime and decrease the period.
    c. For the slope experiment, imperfect rolling conditions of the disc on the slope might be an underlying cause of lower-than-expected experimental values. Although the experimental methods call for repetition of the experiment in the case of slippage, it is likely that the disc slips somewhat at the beginning of its travel.
2. Given that the experimental results differed significantly from the theoretical value and even from each other, it was surprising that the measured times (periods of the pendulum and

time for the disc to roll) were so close together, with standard deviations below 0.5% of the measured values).

References

References should be listed here.

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