All present

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Name: ________________ **ID:** ____________ **Sec:** 2 **Group:** 2 **Date:** 19.06.23

Experiment no: 3

Name of the Experiment: Determination of moment of inertia of a flywheel about its axis of rotation.

Questions on Theory

Questions on Theory

*1) What is a flywheel? [0.25]

Ans: The flywheel is essentially a big sized wheel which has most of its mass distributed over the peripheral region.

*2) What is the moment of inertia of a body? Is it a constant for a body? [0.25]

Ans: The moment of inertia of a body refers to the object's resistance to rotational changes (i.e. Angular acceleration, angular rotation etc). The moment of inertia is not constant for a rigid body.

*3) When the flywheel is set free and the load of mass M moves downward for distance h until it gets detached from the flywheel, then what is the work-done by gravity on the load? [0.25]

Ans: The work done by gravity on the load is, $W = mgh$

*4) At the moment when the load is detached from the flywheel the angular speed of the flywheel is ω. The moment of inertia of the flywheel about its axis of rotation is I. What is the rotational kinetic energy of the flywheel? [0.25]

Ans: The rotational kinetic energy of the flywheel $= \frac{1}{2} I \omega^2$

*5) At the moment when the load is detached from the flywheel the speed of the load of mass M is v. What is the linear kinetic energy of the load? [0.25]

Ans: The linear kinetic energy of the load $= \frac{1}{2} M v^2$

*6) The flywheel makes n_1 revolutions during the period when the load moves downward for distance h. If W_f is the work done against friction per revolution then what is the Energy loss due to friction for n_1 revolutions? [0.25]

Ans: The energy loss due to friction for n_1 revolutions $= n_1 W_f$

*7) The amount of work done by gravity which you wrote in the answer of question 3 provides the kinetic energy to the load, rotational kinetic energy to the flywheel and the energy to work against the friction between the flywheel's axle and its holder. Write down the equation relating them according to the law of conservation of energy. [0.25]

Ans: $Mgh = \frac{1}{2} I\omega^2 + \frac{1}{2} Mv^2 + n_1 W_f$

*8) If r is the radius of cross section of the axle then what is the relationship between the speed of the load v and the angular speed of the flywheel ω at the moment when the load is about to get detached from the flywheel? [0.25]

Ans: Speed of the load $v = \omega r$

*9) After the load is detached from the flywheel the flywheel slows down due to the friction between the axle and its holder. From the moment of detachment the flywheel makes n_2 number of revolutions until it stops rotating. If W_f is the frictional energy loss per revolution then what is the total frictional energy loss for making n_2 revolutions? [0.25]

Ans: The energy loss due to friction for n_2 revolutions $= n_2 W_f$

*10) The rotational kinetic energy which the flywheel attains at the moment when the load gets detached is used to work against friction to make n_2 revolutions. Write down the equation relating this rotational kinetic energy attained by the flywheel and the frictional energy loss after the load gets detached. [0.25]

Ans: $\frac{1}{2} I\omega^2 = n_2 W_f$

*11) At the moment the load gets detached the flywheel's angular speed is ω. It slows down due to friction and finally stops. We assume that this negative angular acceleration is constant. The angular displacement of the flywheel during this period is θ and the measured time is t. What is the relationship among θ, ω and t? [0.25]

Ans: $\omega = \frac{2\theta}{t}$

*12) What is θ in terms of n_2? [0.25]

Ans: $\theta = 2\pi n_2$

13) Using equations (2), (3) and (4) show that, $I = \frac{\left(ght^2 - 8\pi^2 n_2^2 r^2\right)M}{8\pi^2\left(n_2^2 + n_1 n_2\right)}$

[2]

[Use additional page(s) to answer this question]

Ans:

- Draw the data table(s) and write down the variables to be measured shown below (in the 'Data' section), using pencil and ruler BEFORE you go to the lab class.
- Write down your NAME and ID on the top of the page.
- This part should be separated from your Answers of "Questions on Theory" part.
- Keep it with yourself after coming to the lab.

Data

Table 1: Table for determination of n_1, h, n_2 and t

Mass, M (gm)	Path traversed by the load since the moment when the flywheel is made free to rotate, until the load is just detached from the peg. h (cm)	Number of revolutions of flywheel since the moment when the flywheel is made free to rotate, until the load is just detached from the peg. n_1	Number of revolutions of flywheel since the moment when the load is just detached from the peg until the flywheel comes to rest. n_2	Duration of time since the moment when the load is just detached from the peg until the flywheel comes to rest. t (s)	Moment of inertia of the flywheel about its axis of rotation, $I=\frac{(ght^2-8\pi^2n_2^2r^2)M}{8\pi^2(n_2^2+n_1n_2)}$ (gm cm^2)
500	69.7	8	30	23.90	2.16×10^5
400	69.7	8	23	20.10	1.96×10^5
300	69.7	8	17	17.5	1.86×10^5

Table 2: Data for the measurement of the radius of axle, r

Linear scale reading L. S. R (cm)	Vernier scale reading V. S. R (cm)	Mechanical Error M.E. (cm)	Diameter of axle = LSR+VSR ± M.E (cm)	Average value of the diameter of the axle, d (cm)
2.3 cm	0.06 cm	0 cm	2.36	2.36

- READ the PROCEDURE carefully and perform the experiment by YOURSELVES. If you need help to understand any specific point draw attention of the instructors.
- DO NOT PLAGIARIZE data from other group and/or DO NOT hand in your data to other group. It will bring ZERO mark in this experiment. Repetition of such activities will bring zero mark for the whole lab.
- Perform calculations by following the PROCEDURE. Show every step in the Calculations section.
- Write down the final result(s).

Calculations

$$I_{500} = 2.16\times10^5 \text{ gm cm}^2$$

$$I_{400} = 1.90\times10^5 \text{ gm cm}^2$$

$$I_{300} = 1.86\times10^5 \text{ gm cm}^2$$

$$I_{avg} = \frac{I_{500}+I_{400}+I_{300}}{3}$$

$$\therefore I_{avg} = 1.97\times10^5 \text{ gmcm}^2$$

Result:

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Questions for Discussions

1) What type of difficulties did you face while counting the number of revolutions of the flywheel? Please mention. [1]

Ans: The speed of the flywheel makes it quite difficult to count the number of revolution.

2) What is the physical significance of the moment of inertia? [0.5]

Ans: Moment of inertia has the same physical significance of a mass in transitional motion. As ~~The~~ mass of a body is used to calculate inertia in transitional motion. In rotational motion, the greater the moment of inertia is, the greater the angular acceleration.

3) Why does a flywheel have most of its mass distributed around its rim? [0.5]

Ans: In rotational motion the greater the mass concentrated away from the axis the greater the moment of inertia is. That is why a flywheel has most of its mass distributed around its rim, so that the flywheel with a same amount of mass has a greater moment of inertia.

Equation 2:

$$Mgh = \frac{1}{2} I \omega^2 + \frac{1}{2} M \omega^2 r^2 + n_1 W_f$$

Equation 3:

$$\frac{1}{2} I \omega^2 = n_2 W_f$$

Equation 4:

$$\omega = \frac{4\pi n_2}{t}$$

From equation (2) and (3) we can write:

$$I = \frac{2Mgh - M\omega^2 r^2}{\omega^2 \left(1 + \frac{n_1}{n_2}\right)}$$

$$= \frac{2Mgh - \frac{16 M r^2 \pi^2 n_2^2}{t^2}}{\frac{16 \pi^2 n_2^2}{t^2} \times \frac{n_1 + n_2}{n_2}}$$

$$= \frac{2Mght^2 - 16 M r^2 \pi^2 n_2^2}{t^2} \times \frac{t^2 n_2}{16 \pi^2 n_2^2 (n_1 + n_2)}$$

$$= \frac{Mght^2 - 8 M r^2 \pi^2 n_2^2}{8 \pi^2 n_2 (n_1 + n_2)}$$

$$\therefore I = \frac{M(ght^2 - 8\pi^2 n_2^2 r^2)}{8\pi^2 (n_2^2 + n_1 n_2)}$$ (showed)