**Experiment 6: DYNAMICS LAB**

**MOMENTS OF INERTIA: THE FLYWHEEEL**

**BACKGROUND:** A **flywheel** is a mechanical device specifically designed to efficiently store rotational energy. Flywheels resist changes in rotational speed by their moment of inertia. The amount of energy stored in a flywheel is proportional to the square of its [rotational speed](https://en.wikipedia.org/wiki/Rotational_speed). The way to change a flywheel's stored energy is by increasing or decreasing its rotational speed by applying a [torque](https://en.wikipedia.org/wiki/Torque) aligned with its axis of symmetry,

Flywheels are typically made of steel and rotate on conventional bearings; these are generally limited to a maximum revolution rate of a few thousand RPM. High energy density flywheels can be made of carbon fiber composites and employ magnetic bearings, enabling them to revolve at speeds up to 60,000 RPM (1 kHz).

Carbon-composite flywheel batteries have recently been manufactured and are proving to be viable in real-world tests on mainstream cars. Additionally, their disposal is more eco-friendly than traditional lithium ion batteries.

**APPLICATIONS:** Flywheels are often used to provide continuous power output in systems where the energy source is not continuous. For example, a flywheel is used to smooth fast angular velocity fluctuations of the crankshaft in a reciprocating engine. In this case, a crankshaft flywheel stores energy when torque is exerted on it by a firing piston, and returns it to the piston to compress a fresh charge of air and fuel. Another example is the friction motor which powers devices such as toy cars. In unstressed and inexpensive cases, to save on cost, the bulk of the mass of the flywheel is toward the rim of the wheel. Pushing the mass away from the axis of rotation heightens rotational inertia for a given total mass.  
A flywheel may also be used to supply intermittent pulses of energy at power levels that exceed the abilities of its energy source. This is achieved by accumulating energy in the flywheel over a period of time, at a rate that is compatible with the energy source, and then releasing energy at a much higher rate over a relatively short time when it is needed. For example, flywheels are used in power hammers and riveting machines.

Flywheels can be used to control direction and oppose unwanted motions, see gyroscope. Flywheels in this context have a wide range of applications from gyroscopes for instrumentation to ship stability and satellite stabilization ([reaction wheel](https://en.wikipedia.org/wiki/Reaction_wheel)), to keep a toy spin spinning (friction motor), to stabilize magnetically levitated objects (Spin-stabilized magnetic levitation)

**HISTORY:** The principle of the flywheel is found in the Neolithic [spindle](https://en.wikipedia.org/wiki/Spindle_(textiles)) and the potter's wheel, as well as circular sharpening stones in antiquity.

The use of the flywheel as a general mechanical device to equalize the speed of rotation is, according to the American medievalist [Lynn White](https://en.wikipedia.org/wiki/Lynn_White), recorded in the *De diversibus artibus*(On various arts) of the German artisan Theophilus Presbyter (ca. 1070–1125) who records applying the device in several of his machines.

In the Industrial Revolution, James Watt contributed to the development of the flywheel in the steam engine, and his contemporary [James Pickard](https://en.wikipedia.org/wiki/James_Pickard) used a flywheel combined with a [crank](https://en.wikipedia.org/wiki/Crank_(mechanism)) to transform reciprocating motion into rotary motion.

**AIM OF STUDY:** To estimate the moment of inertia of a flywheel and compare experimental results with theoretical calculations.

**LABORATORY EQUIPMENT:** The flywheel has the form of a heavy disc supported via an axle on ball bearings. The axle has a peg for anchoring of the cord. Load hanger, slotted masses, stop watch, meter rule and a cord are also provided for the experiment.

**EXPERIMENTAL PROCEDURE:** Adjust the length of the cord carefully to guarantee that the loop slips off the peg when the weight-hanger just touches the table. Hang slotted mass (m = 7kg), heavy enough to rotate the flywheel if suspended. Boldly mark the rim at the line most visible to you with the loaded hanger just touching the table (alternatively, for this experiment, use the peg as the visual indicator). While holding the flywheel, add potential energy to the system by rotating it n times so that the cord is wound round the axle n times. Avoid overlapping of the cord on the axle. Then, measure the height (h) of the hanger from the table. Release the flywheel to make n rotations before the load hanger hits the table and the cord slips off from the peg. Start the stop watch at the instant the load hanger hits the table and measure the time taken from the flywheel to come to rest. Count the number of rotations () made by the flywheel during this time. Repeat the experiment by changing the value of n.

**RESULTS AND CALCULATIONS:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| n | H | N | T | Ia | Ib |
| 1 | 10.90 | 3.85 | 7.535 | 0.226 | 0.226 |
| 2 | 19.50 | 7.20 | 12.715 | 0.169 | 0.340 |
| 3 | 28.10 | 12.25 | 17.085 | 0.108 | 0.327 |
| 4 | 38.50 | 17.40 | 21.120 | 0.083 | 0.334 |
| 5 | 45.90 | 21.60 | 23.505 | 0.066 | 0.335 |
| 6 | 54.70 | 25.40 | 25.770 | 0.057 | 0.348 |
| 7 | 62.50 | 33.25 | 30.490 | 0.048 | 0.339 |
| 8 | 71.30 | 34.90 | 30.955 | 0.044 | 0.357 |
|  |  |  | Mean= | 0.100125 | 0.32575 |

**Estimating the moment of inertia of the flywheel:**

Given that density = 7850kgm-3, diameter of flywheel = 0.335m, thickness of flywheel= 0.045m

Mass=Density\*Volume, Where Volume of flywheel = πr2t=π\*0.17752\*0.045=4.454 *x*10-3m3

Therefore, mass = 4.454 *x*10-3m3 x 7850 = 34.965kg

Inertia I= (mr2)/2=(34.965\*0.1775\*0.1775)/2=0.5508kgm2

**Estimating the uncertainty in Ia:**

Where

And

Therefore, the uncertainty in Ib

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Where

And

Therefore, the uncertainty in Ib

**OBSERVATIONS:**

**PRECAUTIONS:**

**CONCLUSION**