# Inertial Moment Measurement

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# Contents

# 1 Introduction

Inertial moments are key components when understanding the flight dynamics of an Unmanned Aerial Vehicle. Inertial Moments determine the responsiveness to a plane's control surfaces. For example, the inertial moment, Iyy, controls the planes responsiveness to pitch and determines how fast or slow the plane will respond to the elevator controls.

There are several different ways inertial moments can be determined, the inertial moments can be determined through computer aided design files, hand calculations, or dynamic tests. This paper gives the instructions to determine the inertial moments through a pendulum test. The pendulum test is a relatively simple test to determine the inertial moments of a plane by counting the oscillations and the period of oscillations.

To gain a better understanding of the pendulum test, one should watch the video, presented by The NASA Armstrong Flight Research Center (X-56 Moment of Inertia Tests).

# 2 Equipment

This section describes the setup and equipment of the Inertial Moment Measurement Test.

The following items must be taken into account, otherwise, the test could produce inaccurate measurements.

- Where: Powell Park - Outdoor Exercise Stations
- Conditions: Clear weather with less than 1 mph wind

The following equipment is necessary to conduct the measurements:

- (2) Steel Bar Clamps
- (4) meter of fishing line
- (1) 1/2 in. x 1/2 in. x 36 in. Wood Square Dowel
- (1) Stop Watch
- (5) Screw Eyes
- (4) Lifting Eye Nut
- (1) 2 in. x 4 in. x 4 ft. Dimensional Lumber
- (4) 1 in. wood screws
- (1) Level
- (1) Hot glue gun
- (1) Hot glue stick

# 3 Yaw Inertial Moment Setup and Measurement

Set up the test fixture (Drawn in Figure 1)

1. Cut the 2 in. x 4 in. x 4 ft. lumber to 36 in. in length
2. In the center of the wood, screw [1] screw eye into the top side of the wood face
3. Cut the 1/2 x 1/2 in. wood dowel into [4] 8 in. pieces (this may need to be adjusted, depending on the size of the model)
4. Attach the [4] wood dowel pieces, using the 1 in. wood screws, together to form a square
5. 1/4 in. away from each corner, screw [1] screw eye into the wood
6. On the left side of the wood square, tie a standard fishing Knot with the fishing line to one screw eye
7. Cut 1.1 m of fishing line and tie another knot 1 m away to the screw eye on the center of the 2 in. x 4 in. x 3 ft Lumber
8. Repeat steps [6] and [7] with the other screw eye on the left side of the square
9. Repeat steps [6], [7], and [8] on the right side of the square

At Powell Park

1. Use the [2] Steel Bar Clamps to secure the 2 in. x 4 in. x 3 ft. Lumber to the exercise bar
2. Use the level to verify the hanging wood square is level in all directions
3. Once the wood square is confirmed to be level, place the F-16 on the tray, facing forward, with the center of gravity in the middle of the square
4. Lightly push the rear of the plane and start the timer

5. Count the number of oscillations

6. Record the total time oscillations were occurring in table 1

7. Record the total number of oscillations in table 1

Once the test is completed, transfer the information written in table 1 to the excel file on the Github, here.

# 4 Pitch Inertial Moment Setup and Measurement

Set up the test fixture

1. Use the same lumber used in the Yaw Inertial Moment Setup
2. Using the Hot Glue Gun, glue the Lifting Eye Nut to the approximate locations show in Figure 2

At Powell Park

1. Use the [2] Steel Bar Clamps to secure the 2 in. x 4 in. x 3 ft. Lumber to the exercise bar
2. The next two steps should be completed so that the plane is balance between the two ties
3. Tie the fishing line, 1 meter in length, to one side of the lifting eye nut on the left side of the fuselage (towards the cockpit) and to the screw eye in the center of the wood
4. Tie fishing line, 1 meter in length, to one side of the lifting eye nut on the right side of the fuselage (towards the tail) and to the screw eye in the center of the wood

To collect the data

1. Lightly push the underside side of the plane and start the timer
2. Count the number of oscillations
3. Record the total time oscillations were occurring in table 1
4. Record the total number of oscillations in table 1

Once the test is completed, transfer the information written in table 2 to the excel file on the Github, here.

# 5 Roll Inertial Moment Setup and Measurement

Set up the test fixture

1. Use the same lumber used in the Yaw Inertial Moment Setup
2. Using the Hot Glue Gun, glue the Lifting Eye Nut to the approximate locations show in Figure 3

At Powell Park

1. Use the [2] Steel Bar Clamps to secure the 2 in. x 4 in. x 3 ft. Lumber to the exercise bar
2. The next two steps should be completed so that the plane is balance between the two ties
3. Tie the fishing line, 1 meter in length, to one side of the lifting eye nut on the left side of the fuselage and to the screw eye in the center of the wood
4. Tie fishing line, 1 meter in length, to one side of the lifting eye nut on the right side of the fuselage and to the screw eye in the center of the wood

To collect the data

1. Lightly push the underside of the plane and start the timer
2. Count the number of oscillations
3. Record the total time oscillations were occurring in table 3
4. Record the total number of oscillations in table 3

Once the test is completed, transfer the information written in table 2 to the excel file on the Github, here.

# 6 Appendix

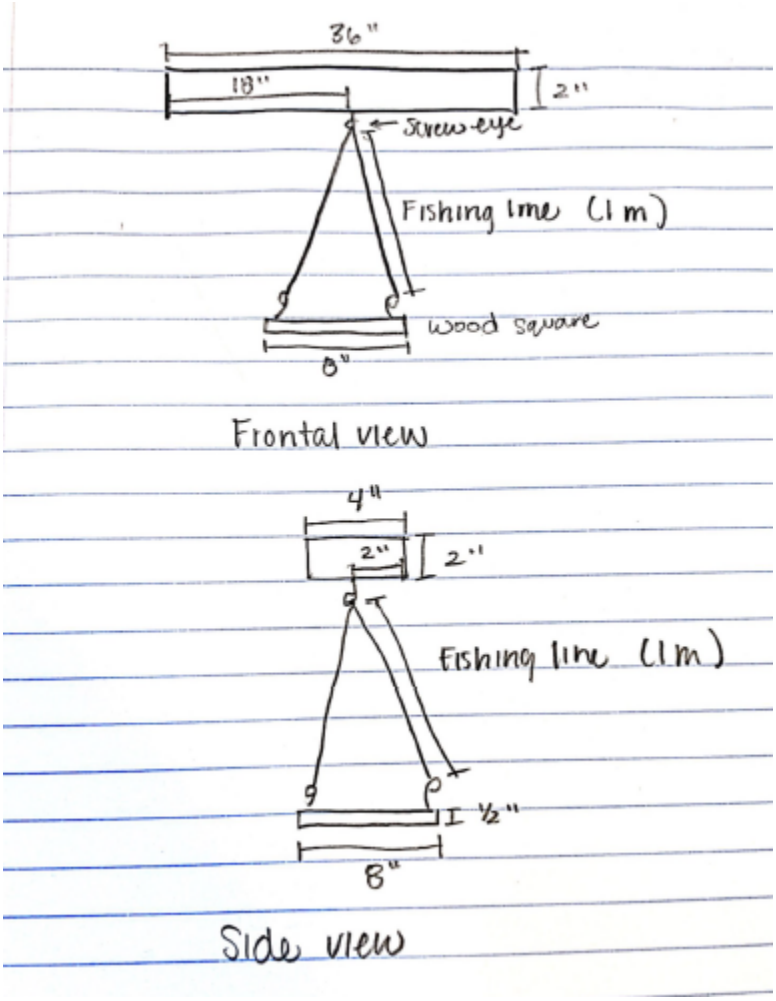


**Figure 1:** Setup for Yaw Moment

**Figure 2:** Setup for Pitch Moment

**Figure 3:** Setup for Roll Moment

| Test | Ref. Length (m) | No. of oscillations | Time for oscillations (Sec) | Period |
|---|---|---|---|---|
| 1 | 1 | | | |
| 2 | 1 | | | |
| 3 | 1 | | | |

**Table 1:** Measured Period and Values for Yaw Moment of Inertia

| Test | Ref. Length (m) | No. of oscillations | Time for oscillations (Sec) | Period |
|---|---|---|---|---|
| 1 | 1 | | | |
| 2 | 1 | | | |
| 3 | 1 | | | |

**Table 2:** Measured Period and Values for Pitching Moment of Inertia

| Test | Ref. Length (m) | No. of oscillations | Time for oscillations (Sec) | Period |
|---|---|---|---|---|
| 1 | 1 | | | |
| 2 | 1 | | | |
| 3 | 1 | | | |

**Table 3:** Measured Period and Values for Rolling Moment of Inertia