Iowa State University

Aerospace Engineering

AER E 322 Lab 01
Practice Experiment and Data Analysis

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Aerospace Structures Laboratory Report
Lab 01 Practice Experiment and Data Analysis

Section 4 Group 2
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Chapter 1

Pre-Lab

1.1. Introduction

Aircraft wings undergo oscillations and other random forces while in flight. This lab replicates and analyzes some of the forces and oscillations a wing will experience in flight while also serving as an introduction to the PASCO tool kits and data processing. To simulate the wing, we used a cantilevered aluminum beam, and to generate and measure the oscillations, we used a PASCO tool kit—specifically the PASCO wave driver, displacement sensor and motion sensor. There were three rounds of testing; each additional round of testing introduced a new variable into the beam movement that changed the shape of the data. The data was collected using the PASCO tool kit and software provided. After the lab, we analyzed and processed the data in Python to how each variable effected the oscillation of the beam.

1.2. Objectives

During this lab, our primary objectives were to:

1. Learn how to record data under dynamic conditions and analyze or post-process the data.
2. Observe approximately how a common aerospace structural material might respond to oscillatory forces.

3. Gain familiarity with the PASCO tool kit and the PASCO Capstone software.

1.3. Hypothesis

1.3.1. Test 1

We predict this test will provide the cleanest data of the three tests. Since the only force acting on the beam should be from the wave driver, we expect the displacement graph to shown a uniform and steady wave—matching the oscillations of the wave driver. The data from this test should closely match the oscillations of an airplane wing in very steady flight.

1.3.2. Test 2

This test adds a spring-loaded weight to the cantilevered beam. Due to the oscillations of the spring loaded weight, we expect to see sudden highs and lows in the data corresponding with when the spring-loaded weight is in compression or tension respectively. The data from this test should demonstrate the oscillations of the wing in steady flight if there is an additional oscillatory or vibrational force simultaneously acting on the wing.

1.3.3. Test 3

This test is similar to Test 2 (see Section 1.3.2) except a third significant force has been introduced. Due to the addition of arbitrary impulses being applied by hand to the free end of the beam, we expect the data to show large peaks and dips in the data correlated with the timing of the impulses. The data from this test should demonstrate the oscillations of real flight as described in Section 1.3.2 but also how the wing might react during periods of high turbulence where sudden, large impulses may act on the wing.

Chapter 2

Lab Work

2.1. Variables

2.1.1. Independent Variables

Wave Driver Frequency

The frequency of the wave generated by the PASCO wave driver.

Wave Driver Amplitude

The maximum voltage the wave driver will use when oscillating, proportional to the displacement of the wave driver arm.

Sampling Frequency

The time intervals at which the PASCO motion sensor or displacement sensor poll the position or displacement of the beam. Sensor with a higher sampling frequency will collect more data in the same amount of time.

Smoothing Span

The number of elements after a given element used to calculate a rolling mean while data processing. A small smoothing span will better preserve the shape of the data; whereas, a larger smoothing span will better reduce noise and outliers.

Time

Each test was run for exactly 15 s, measured in 0.01 s intervals.

2.1.2. Dependent Variables

Displacement/Position

The change in location of the cantilevered beam from its equilibrium position, measured closer to the free end along a perpendicular vertical axis.

Best Fit Curve

The line of best fit or fit curve is a normalized curve matching the raw or smoothed data and depends on the shape and magnitude of the displacement data.

2.2. Work Assignments

Refer to Table 2.1 for the distribution of work during this lab.

2.3. Materials

The materials required for this lab include: cantilever aluminum beam, spring, weight, Styrofoam pad, tape, round point-tip "needle" displacement sensor, C-clamps, wooden 2"x4", bench vice, string, computer with PASCO Capstone software, clamp stand with clamps, PASCO 850 Universal Interface, PASCO mechanical wave driver, and a PASCO non-contact motion sensor.

2.4. Apparatus

Figure 2.1 shows the fully assembled lab apparatus. For run 1, the weight was removed from the spring. For runs 2 and 3, the weight was added back to the apparatus and the displacement sensor—the needle-like device on top of the beam—was removed.

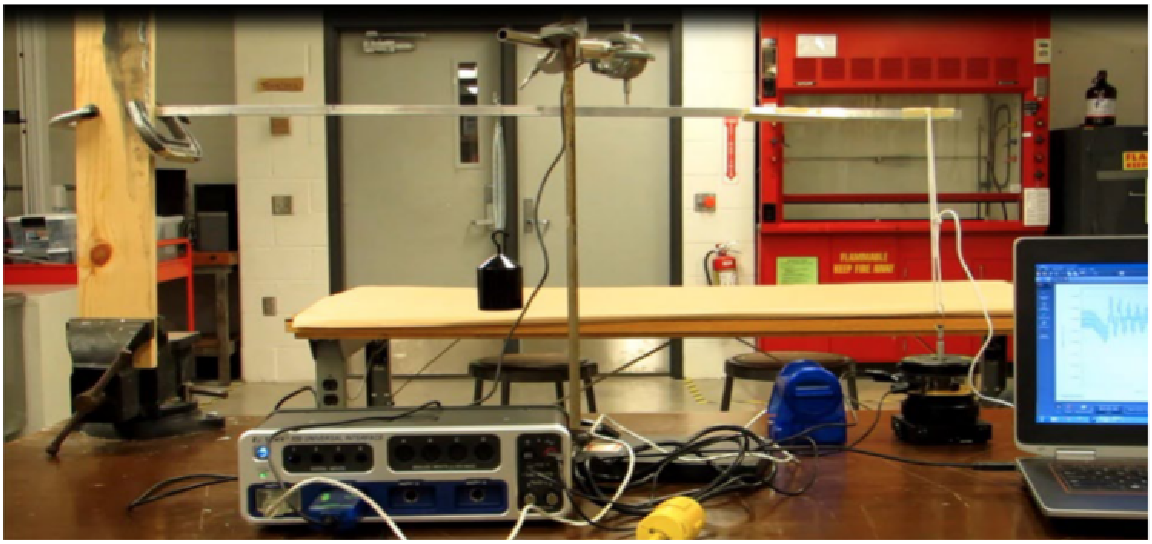

Figure 2.1: Lab apparatus completely set up, including the spring, weight, and displacement sensor. Image from the *Lab 1 Practice Experiment and Data Analysis* manual [1]. Copyright 2023 by Thomas Chiou.

As shown in Figure 2.1, the left side of the beam is fixed to the board and the right side is attached to the wave driver with string. The rectangular, gray box in the foreground is the PASCO 850 Universal Interface, and the blue device in the midground is the motion sensor. The motion sensor must be positioned directly underneath the piece of white foam taped to the bottom of the beam with at least 15 cm between the sensor and the foam.

2.5. Procedures

2.5.1. Setup

Assemble the apparatus as described in Section 2.4. Ensure that the styrofoam reflector plate is at least 15 cm away from the motion sensor before running any tests. Launch the PASCO Capstone software, and turn on the PASCO 850 Universal Interface. Check that both the "needle" displacement sensor and motion sensors are recognized by the software. Once the sensors are recognized, configure the software to display two graphs "by selecting the corresponding icon from the on-screen template" [1]. Next, click on each axis label on the graphs, and set the y-label of the displacement sensor graph to "displacement", and "position" for the motion sensor. For both graphs the x-label will be "time". Refer to Figure 2.2 to see how the graph layout should look.

Figure 2.2: The graph screen of the PASCO Capstone software fully configured for this lab. Image from the *Lab 1 Practice Experiment and Data Analysis* manual [1]. Copyright 2023 by Thomas Chiou.

2.6. Data

Table 2.1: Work assignments for lab 01.

Task	**Matthew**	**Peter**	**Natsuki**
Lab Work			
Date Recording		X	
Exp. Setup	X		
Exp. Work			X
Exp. Clean-Up	X	X	X
Data Processing			
Data Import	X		
Smoothing	X	X	
Line of Best Fit	X	X	X
Report			
Introduction			X
Objectives		X	
Hypothesis	X		
Variables		X	
Materials		X	
Apparatus		X	
Procedures	X		
Data	X		
Analysis	X	X	X
Conclusion			X
References			X
Appendix			X
Revisions	X	X	X
Editing	X		

Chapter 3

Conclusion

3.1. Analysis

3.2. Conclusion

References

[1] Thomas Chiou. *Lab 1 Practice Experiment and Data Analysis*. Jan. 26, 2023, pp. 2–5.

Appendix A

Graphs

Appendix B

Code