WILLIAM E. BOEING DEPARTMENT OF
AERONAUTICS & ASTRONAUTICS
College of Engineering

AA421
System Test Plan

SPACE Lab

Part Name: _____

Part Number: _____

Date: _____ / _____ / _____
yyyy mm dd

Test Team:

Name	Initials

Introduction

This experiment is designed to verify the ability of the test stand assembly to resolve deflections such that impulse bits and steady-state thrusts of an operating pulsed plasma thruster (PPT) can be measured. Corresponding to system requirements 3 and 4, the test stand assembly must be able to resolve impulses between 10 μN*s to 100 mN*s ± 5 μN*s and steady-state thrusts between 0.1 mN to 0.1 N ± 0.05 mN respectively. This test plan is to accompany the test procedure for the system test.

Test Constraints

Constraint	Description	Value
$m_{p1,p2}$	Total mass of pendulum and shelf	1.37 kg - 1.78 kg +/-5%

Test Parameters

Variable	Description	Values / Range
T	Temperature of test environment	15-25°C
m_{p1}	Mass of pendulum configuration 1 (metal chamber configuration)	1.37kg+/-5%
m_{p2}	Mass of pendulum configuration 2 (crystal chamber configuration)	1.78kg +/-5%

Test Variables

Variable	Description	Range
m	Mass of test masses	0.2-10.1 kg, given mass +/-1%
F	Flexure selection	Impulse flexure sizing
C_1	Shelf configuration 1 (metal chamber configuration)	
C_2	Shelf configuration 2 (crystal chamber configuration)	

Measurements

Variable	Description	Values / Range
d	Displacement of pendulum due to loading	Values must not diverge relative to previous measurements by greater than an order of magnitude
t_s	Pendulum settling time	
V_p	Peak voltage	
ω	Pendulum oscillation frequency	

Test Matrix

1.0 Impulse Testing

M.1.1 - Test Matrix

Flexure Set 1					
Shelf 1			Shelf 2		
Thruster + Shelf Mass	3.6 kg		Thruster + Shelf Mass	9.7 kg	
Test 1	Waterfall with Damper Calibration Mass	50 g	**Test 5**	Waterfall with Damper Calibration Mass	75 g
Test 2	Waterfall Without Damper Calibration Mass	50 g	**Test 6**	Waterfall Without Damper Calibration Mass	75 g
Test 3	Damping (No Waterfall) Calibration Mass	50 g	**Test 7**	Damping (No Waterfall) Calibration Mass	75 g
Test 4	No Damping, No Waterfall Calibration Mass	50 g	**Test 8**	No Damping, No Waterfall Calibration Mass	75 g
			Test 9	Waterfall with Damper Calibration Mass	100 g
			Test 10	Waterfall Without Damper Calibration Mass	100 g
			Test 11	Damping (No Waterfall) Calibration Mass	100 g
			Test 12	No Damping, No Waterfall Calibration Mass	100 g

Flexure Set 2

Shelf 1	Thruster + Shelf Mass 3.6 kg
Test 13	Waterfall with Damper Calibration Mass 50 g
Test 14	Waterfall Without Damper Calibration Mass 50 g
Test 15	Damping (No Waterfall) Calibration Mass 50 g
Test 16	No Damping, No Waterfall Calibration Mass 50 g

Shelf 2	Thruster + Shelf Mass 9.7 kg
Test 17	Waterfall with Damper Calibration Mass 75 g
Test 18	Waterfall Without Damper Calibration Mass 75 g
Test 19	Damping (No Waterfall) Calibration Mass 75 g
Test 20	No Damping, No Waterfall Calibration Mass 75 g
Test 21	Waterfall with Damper Calibration Mass 100 g
Test 22	Waterfall Without Damper Calibration Mass 100 g
Test 23	Damping (No Waterfall) Calibration Mass 100 g
Test 24	No Damping, No Waterfall Calibration Mass 100 g

Test Log

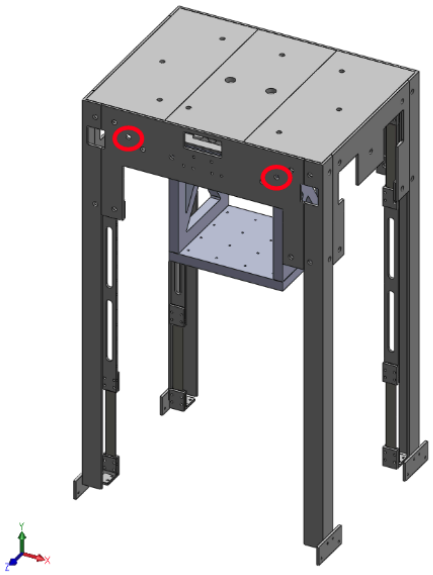
M.1.2 - Test Log

Run #	Flexure Thickness (in)	Total mass (kg)	Applied Impulse (N*s)	Trace Save Name	Peak Voltage (V)	Settling Time (s)

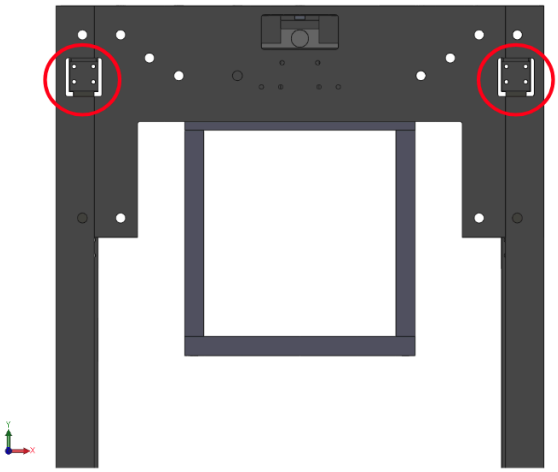
PRD 1 Flexure Replacement Procedure (~35 min)

PRD 1.1 Pendulum Arm Removal

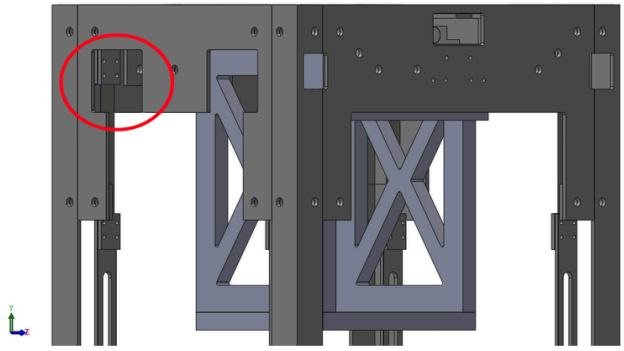
1. Insert 3 inch long, 0.25 inch diameter bolts into holes indicated with red circles below. These bolts should fit under the top of the pendulum in order to support the pendulum while flexures are removed.



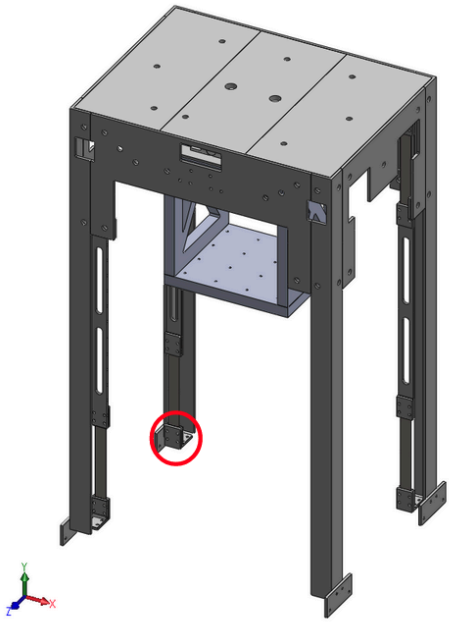
2. Once the pendulum top is supported, access bolts through cut out, indicated in red circles below, using a size PH1 phillips head screwdriver.



Access the nuts on the other side of the pendulum arm through the cut outs indicated with red circles below. Using a ¼” box end wrench to counter hold the nuts, fully loosen each bolt using the screwdriver. Remove each nut, but leave bolts and the upper flat bracket in place to keep the pendulum arm supported.



3. At lower flexure access nuts and bolts on corner bracket indicated below in red circles



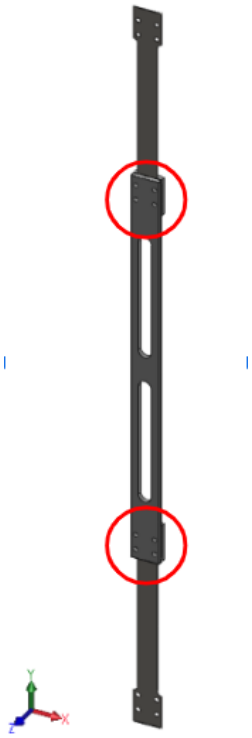
Using socket driver with 3/16” inch socket attached, loosen nuts on lower flexures while counter holding bolts using ¼” box end wrench. Remove nuts, bolts, and the lower flat bracket from the pendulum arm.

4. Remove the pendulum arm without corner brackets, shown below.

5. Repeat procedure for other 3 pendulum arms.

PRD 1.2 Flexure Removal

6. With pendulum arms removed from pendulum, remove nuts, brackets, and bolts from pendulum arms and remove flexures. Place removed flexures with flexures of the same thickness to avoid confusion.

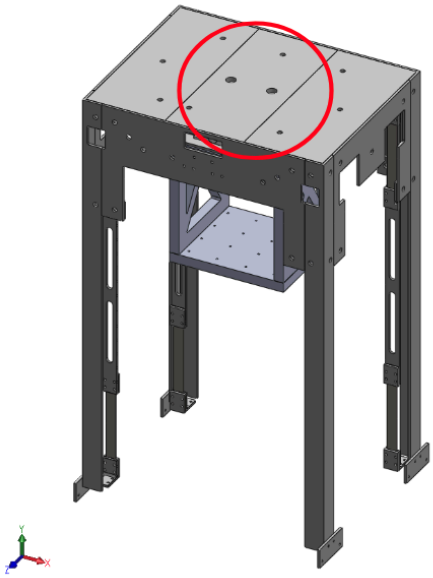


7. Install new flexure onto the pendulum arm by reversing PRD 1.2.
8. Install pendulum arms with new flexures by reversing PRD 1.1.
9. Remove 0.25” support bolts from the pendulum frame.

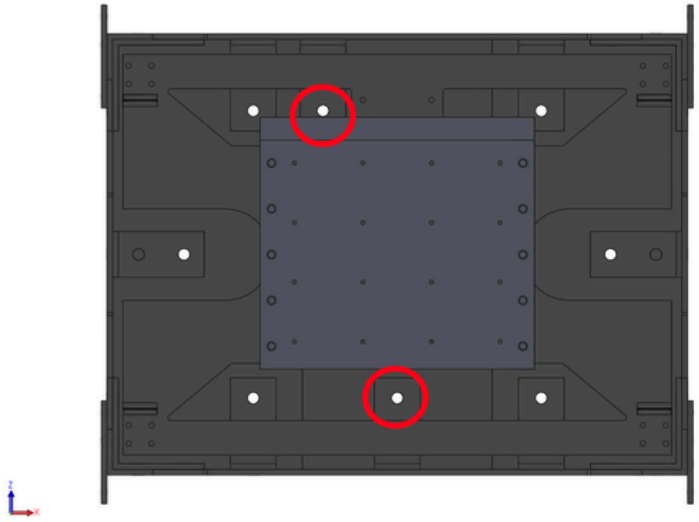
PRD 2 Thruster Shelf Change Procedure (~15 min)

PRD 2.1 Pendulum Frame Top Removal

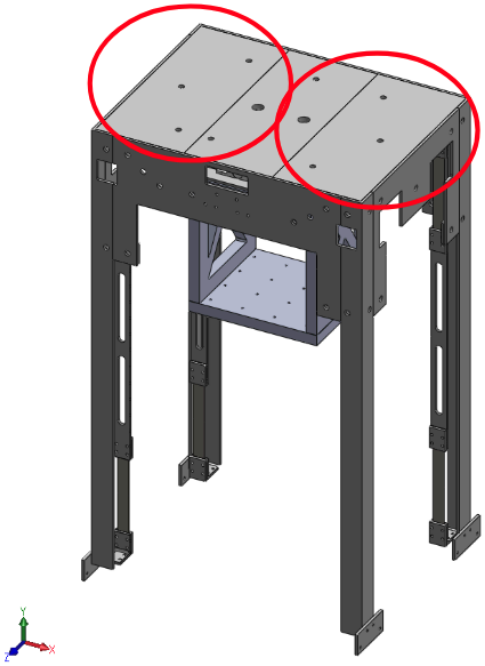
1. Remove center panel of top of pendulum frame, indicated in red circle below.



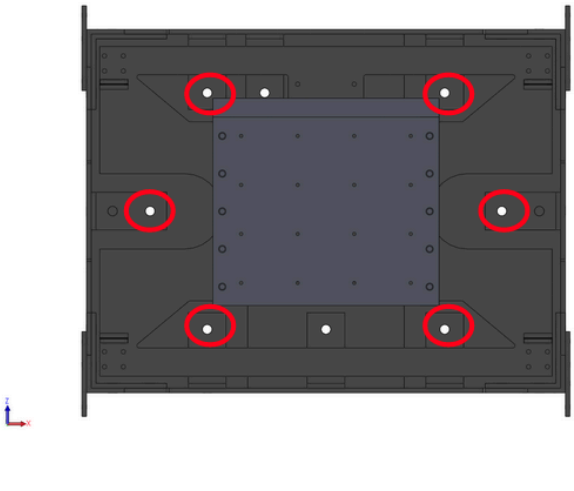
Bolts can be accessed from top using a ⅜” box end wrench. The nuts are accessed from below, indicated below, using a socket driver with a 7/16” socket attached. Using ½” holes in the center of the panel to remove the panel.



2. Remove side panels on top of pendulum frame, indicated in red circles below.



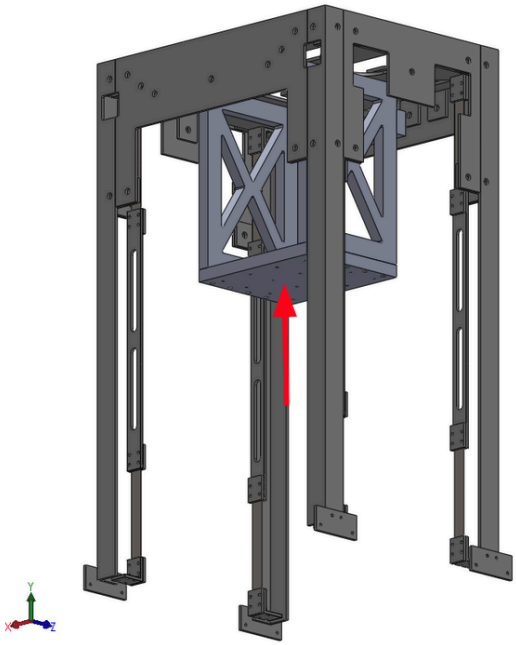
Bolts can be accessed from top using a ⅜” box end wrench. The nuts are accessed from below, indicated below, using a socket driver with a 7/16” socket attached.



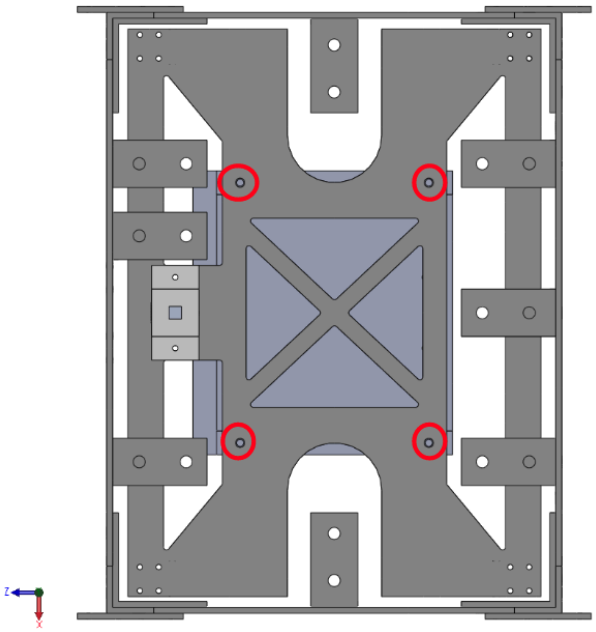
Remove panels from the pendulum frame.

PRD 2.2 Shelf Removal

3. Support thruster shelf from below with one hand, as indicated with red arrows below



4. While supporting the shelf from step 3, remove 4 bolts, indicated in red circles below, securing the thruster shelf to the pendulum using a socket driver with a 5/16” socket.



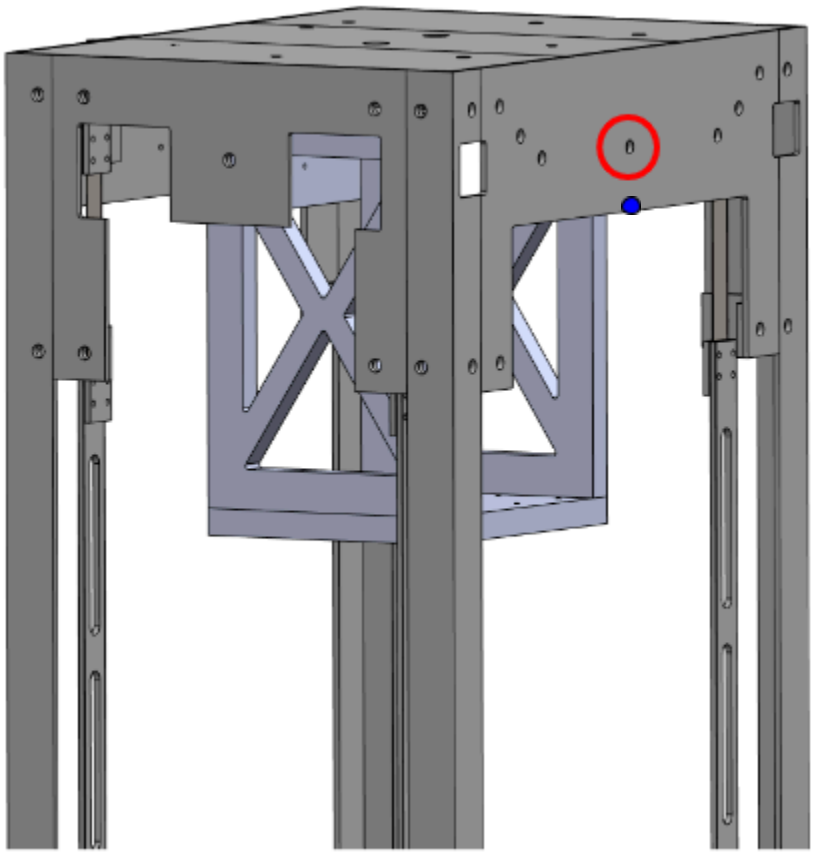
5. Remove thruster shelf from pendulum, store shelf in box.

6. Reinstall new thruster shelf by reversing PRD 2.2.

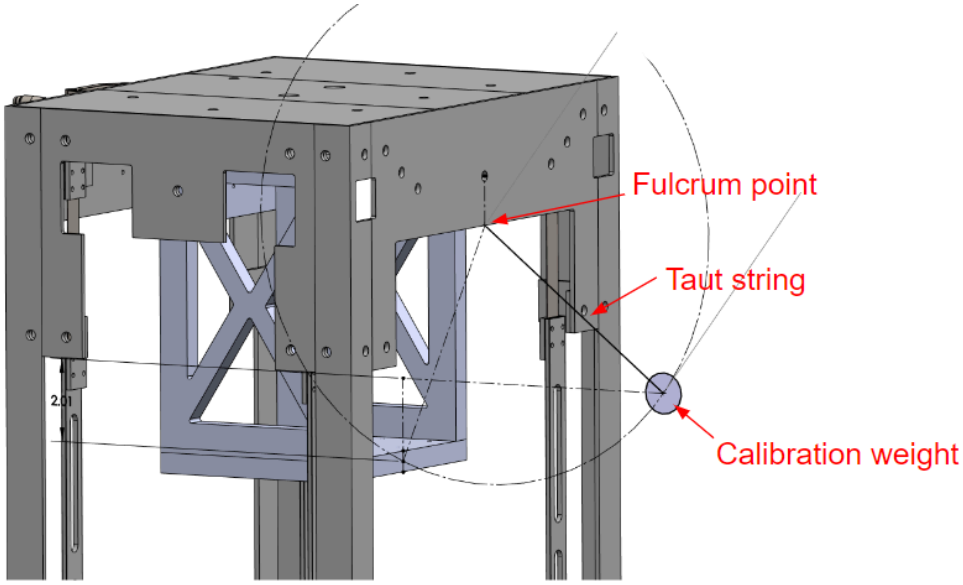
7. Reinstall pendulum frame top panels by reversing PRD 2.1.

PRD 3 Atmosphere Impulse Application Procedure (~1 hour)

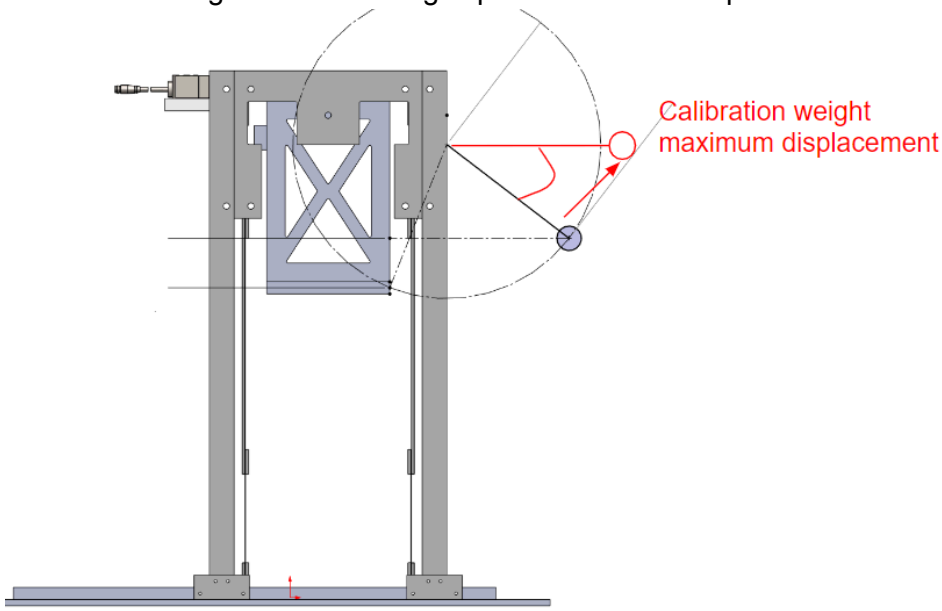
1. At the circled hole on the assembly, screw on a ¼” bolt, leaving ½” of the bolt shaft exposed.



2. Using a string, tie a knot on the exposed bolt threads, leaving an ample length slack.
3. Tape down the length of string to the face of the frame, such that the swinging motion of the string is at the bottom of the face (blue dot).
4. Tie the calibration weight to the other end of the string, making sure to have a sufficient string length between the edge of the frame and weight such that the weight collides with the pendulum.



5. Immediately prior to the impulse test, raise the calibration weight, keeping the string taut.
6. Hold calibration weight until the string is parallel to the floor plane.



7. Release the weight, and ensure that the scope recorded the resultant oscillation of the test stand pendulum.
8. Save raw voltage data from the scope to a flash drive.
9. Repeat steps 5-8 for all trials.