Ian Dwyer, Emmet Farnan, Christopher Jarocki, Graham Johnson, Alexa Klaus, Sam Nemeth
Aerospace Structures

Homework 10 – Extra Credit
Classical Flutter: Effects of Pitching and Heaving Spring Coefficients

In order to observe the effects of pitching and heaving spring coefficients on the flutter behavior of a wing, a range of both pitching and heaving spring coefficients were used in the wingflutter15dec01.f Fortran code and the input.dat file. The behavior of the airfoil under these different constraints was then observed by producing a movie using Matlab's 'movie2avi' command. The values used and resulting behaviors can be found in Table 1, below.

**Table 1.** Comparison of Values Used and Resulting Behavior

K_y	K_θ	Behavior
0.01	0.01	Pitching and Heaving
0.5	0.5	None
0.1	3	None
3	0.1	Pitching
0.1	0.1	Pitching and Heaving
0.5	0.1	Pitching and Heaving
1.5	0.5	None
0.1	0.5	None
0.01	0.4	None
0.75	0.75	None
0.1	1.5	None
1	0.1	Pitching and Heaving
2	0.1	Pitching and Heaving
0.3	0.3	Pitching and Heaving
0.4	0.4	None
2.5	0.4	None
1	1	None
3	0.3	Pitchng and Heaving
0.01	0.1	None
3	3	None
2	2	None
2.5	0.1	Pitching and Heaving

Once the varying behaviors were determined for the different values of the spring constants, Matlab was used to plot the points and come up with a phase diagram. The plot can be found in Figure 1, below.
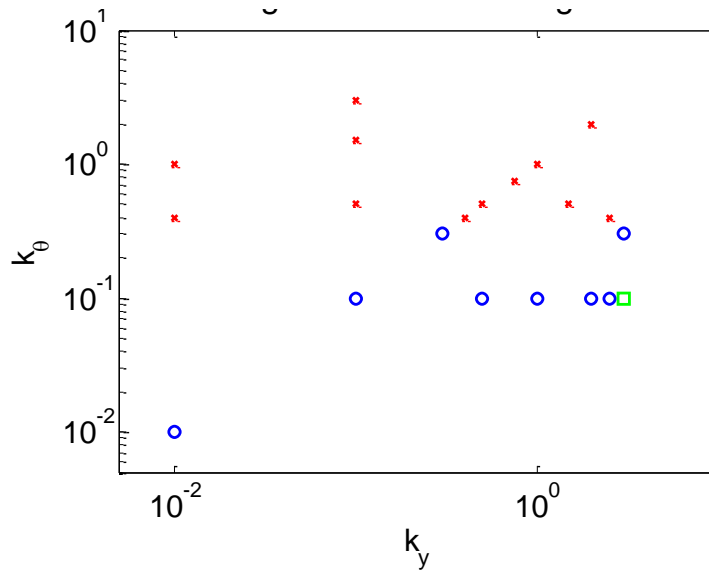
Figure 1. Wing Flutter Plot

       In the plot above, the red x's show the values where the wing did not pitch or heave. The blue circles show values where the wing both pitched and heaved. Finally, the green square shows the value where the wing pitched only. Once the above plot was obtained, we estimated the areas for the different phases to create a phase diagram, shown in Figure 2, below, using the same color scheme.
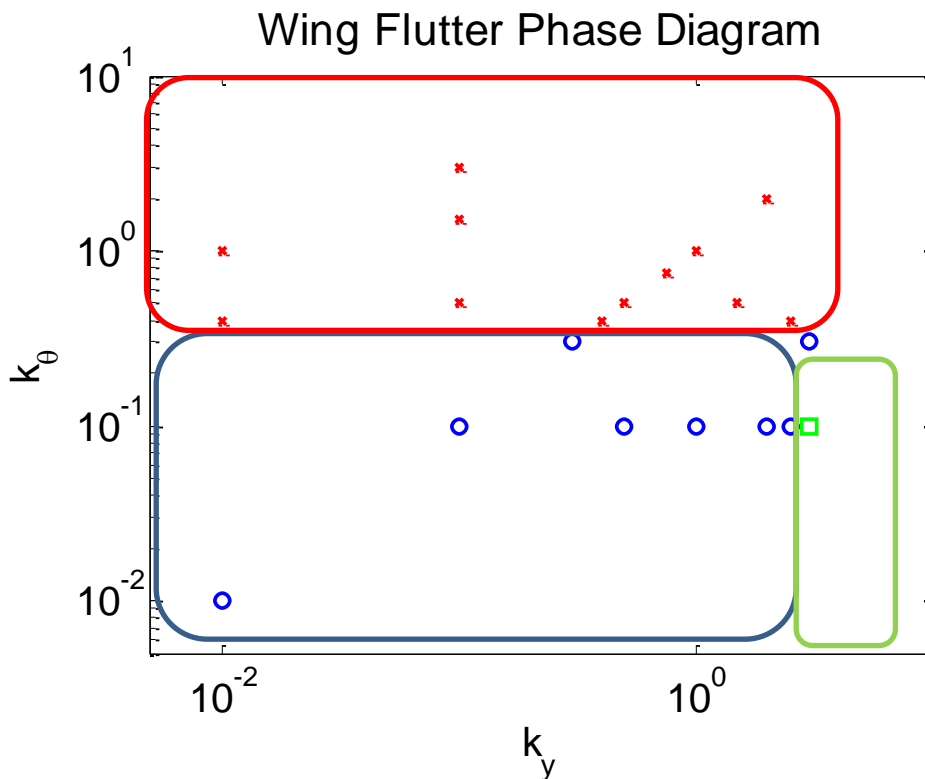
Figure 2. Wing Flutter Phase Diagram

The flutter behavior can be split up into three phases: pitching and heaving, pitching only, and no pitching or heaving. As seen in the phase diagram, there are outlying values (such as when the heaving spring constant has a value of 3 and the pitching spring constant value of 0.3. However, the wing does follow the phase diagram pretty closely for most of the other values.

If more time and computing resources were available, in the future we would want to explore more values of the spring constants and include more significant figures to find the exact values where the phases changed. We would also want to explore the outlier values and their cause.