Department of Mechanical Engineering
Indian Institute of Technology Madras

ME 7224 Modal Analysis of Mechanical Systems

End Semester Exam (Take Home)

Date: May 13, 2023 Maximum Marks: **70**
Time: 24 hours

1. A cantilever beam has been tested using 8 points along its length. Point #1 is at the free end and Point #8 is near the fixed support. The accelerance FRF data, H^a_{ij} for $i = 1$ and $j = 1, 2, \cdots, 8$, is available using the link `https://docs.google.com/spreadsheets/d/1LHWI7mK8yCGlikVYcqLPs-oBO_Pyiq_crmn7tgkuoHc/edit?usp=sharing`. Please note that this data has the units m/(s^2 lbf).
   (a) Plot the magnitude as well as the real and imaginary parts of the receptance FRFs, H_{11} and H_{14}, for the frequency range $5 \leq f \leq 450$ Hz. (5)
   (b) For the second and third modes, use peak-picking and circle fit SDOF methods to estimate the natural frequency, damping parameter (assume it is structural damping) and modal constants; plot the mode shapes. (18)
   (c) Regenerate the accelerance FRFs from the fitted data (H^a_{11} and H^a_{15}) and check how good a fit it is with the experimental accelerance FRFs; frequency range is $50 \leq f \leq 450$ Hz. Comment on the results obtained. (7)
   (d) Find out the residual stiffness and mass for improving the fit for H^a_{12} and H^a_{16}. (5)
2. Use the same experimental data from the previous question and do the following:
   (a) Use the rational fraction polynomial (RFP) method (based on orthogonal polynomials) to extract the natural frequencies, damping ratios (assume viscous damping) and mode shape parameters, in the frequency range $5 \leq f \leq 125$ Hz using the receptance FRFs. Assume $m = 2$ for this exercise (18)
   (b) Now vary m from 3 to 6 and generate the parameters as before. Comment on the results you obtain. (10)
   (c) Regenerate the accelerance FRFs and compare it with experimental data for H_{11} and H_{17}; comment on your results. (7)