Animation Software for Vibrations Courses

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Abstract – Three software modules for upper-undergraduate/first-graduate-level vibrations courses are presented. The modules treat (1) single-degree-of-freedom spring-mass systems, (2) up to three-degree-of-freedom systems, and (3) transverse vibration of uniform beams. All modules use the Visual Basic platform and have been used as supplementary material in a senior-level vibrations course. Student feedback is included.

Keywords: Animation software, vibrations, teaching technology

INTRODUCTION

The history of these particular modules dates back to the early 1980's when personal computers first became required for undergraduate engineering students at Virginia Tech. The first efforts by the senior author at animation of dynamic systems were DOS-based [Kraige, 1]. A later generation was based on the Authorware Platform [Kraige, 2]. The latest efforts are written in either Flash or Visual Basic [Kraige, 3]. Regardless of the platform, the idea is the same over the years: If students are able to see an animation of the systems that they are studying, especially for their own choice of conditions, they are much more likely to better understand the material.

These particular modules were prepared for use in the senior course in vibrations which is required as part of the B.S. in Engineering Science and Mechanics. The modules would be useful for any first course in vibrations. Visual Basic was chosen as the platform because of its animation capabilities and also because the end-product .exe files are truly standalone, needing no attendant player or other software.

DESCRIPTION OF THE SOFTWARE

1. Single-Degree-of-Freedom Module

This module gives the user the ability to enter all conditions and then view the resulting motion of single-degree-of-freedom spring-mass-damper systems. Figure 1 shows the popup input menu. In the main animation mode (Figure 2), the motion is shown in near real time. As the simulation of the system occurs at the left of the screen, a time-history of the motion is generated at the lower right. Note that a scaled red arrow attached to the mass indicates the force magnitude and direction, and a black pointer serves as an indicator of the instantaneous displacement. If the system is forced, plots of the magnification factor and the phase angle, both as functions of the nondimensionalized driving-frequency ratio, are shown in the upper part of the screen, with red dots indicating the present conditions. Various items of interest, such as the natural frequency, the critical damping value, the amplitude of the steady-state solution, etc., are always immediately available. In addition to a brief set of instructions on using the software, a comprehensive set of prepared tutorials with judiciously chosen conditions is available.

A second mode of use, the parameter-variation mode (Figure 3, shown larger) allows the user to continuously vary the conditions of the motion and immediately see the effects of a single variation on a plot of the time-history of the

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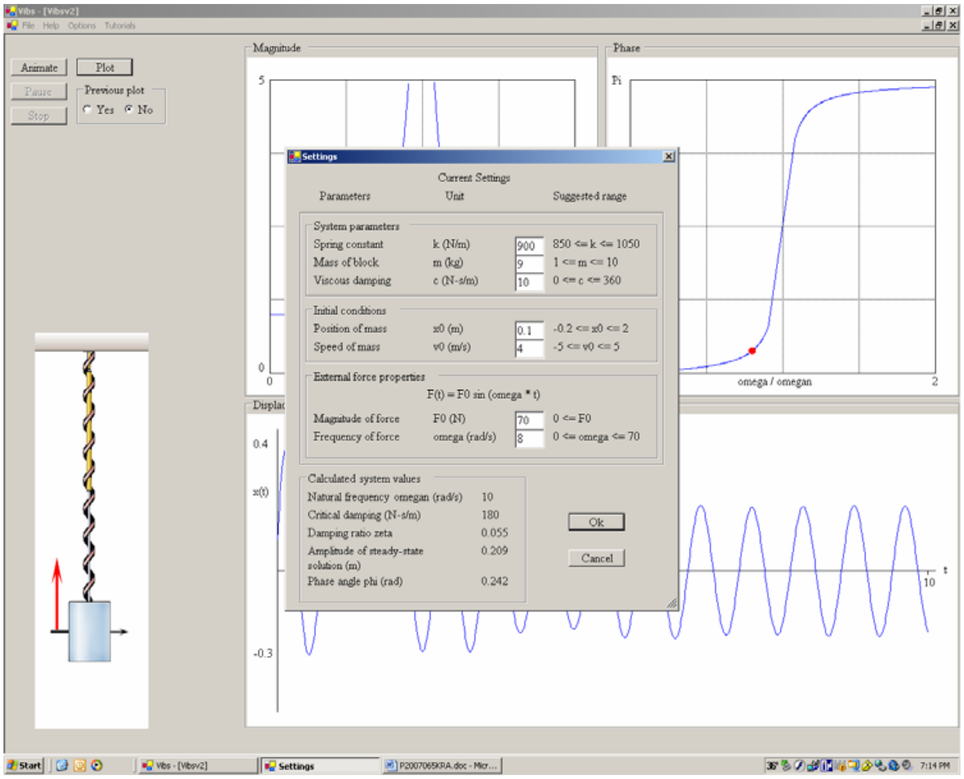

Figure 1. Animation input page for single-degree-of-freedom systems

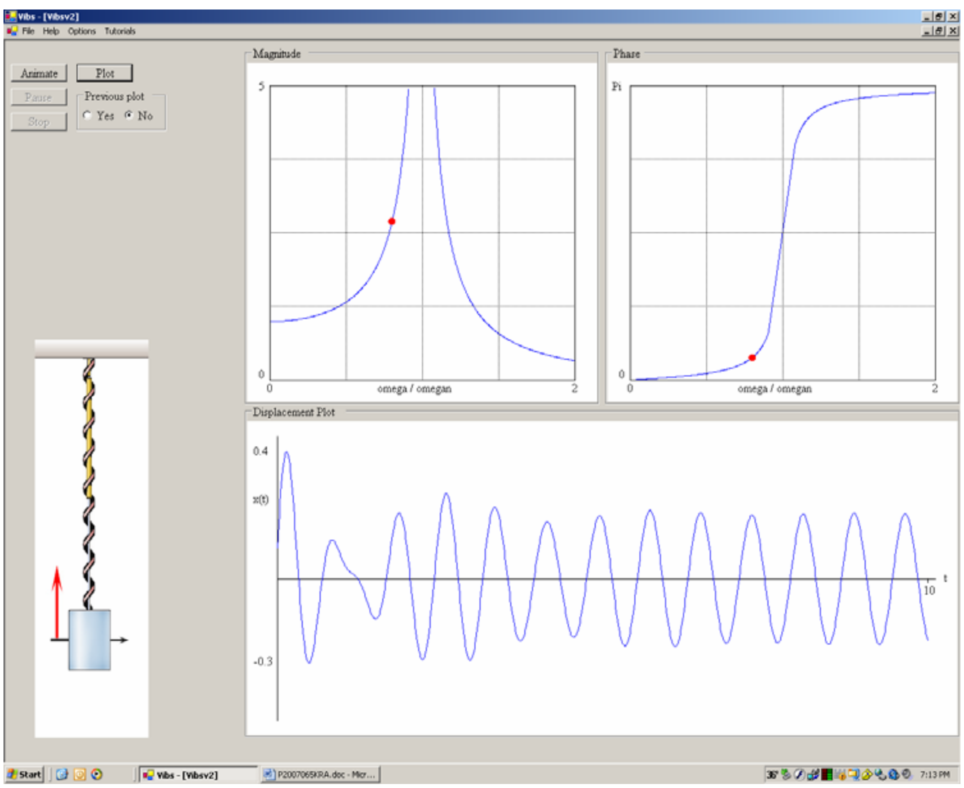

Figure 2. Corresponding animation page

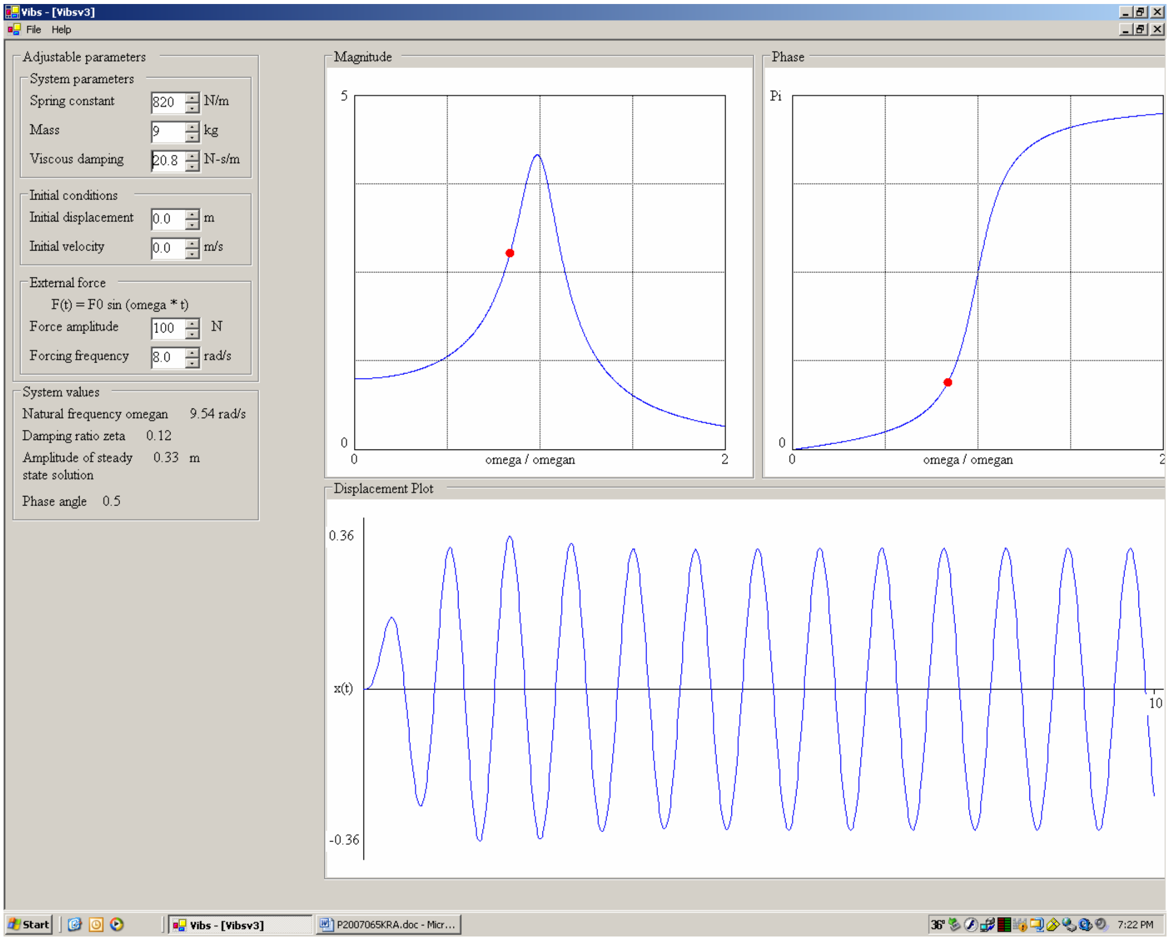

Figure 3. The parameter-variation mode for single-degree-of-freedom systems

motion, as well as on the plots of the magnification factor and phase angle. As one parameter is varied, all other parameters remain constant.

2. Multi-Degree-of Freedom Module

This module is similar to the first one except that up to three degrees of freedom (dof) are allowed for the animation mode, and the second mode (the parameter-variation mode) is not present. As indicated at the upper right of Figure 4, there is the option of specifying whether a bottom spring is present for the case of two degrees of freedom (this allows the demonstration of the undamped, unforced beat phenomenon shown in Figure 4.)

If one specifies external forces (Figure 5), there is the opportunity to specify harmonic forces of any amplitude, driving frequency, and phase-lag angle – one force for each mass. As before, a scaled red arrow attached to the mass indicates the force magnitude and direction, while a black pointer attached to the mass serves as an indicator of the instantaneous displacement.

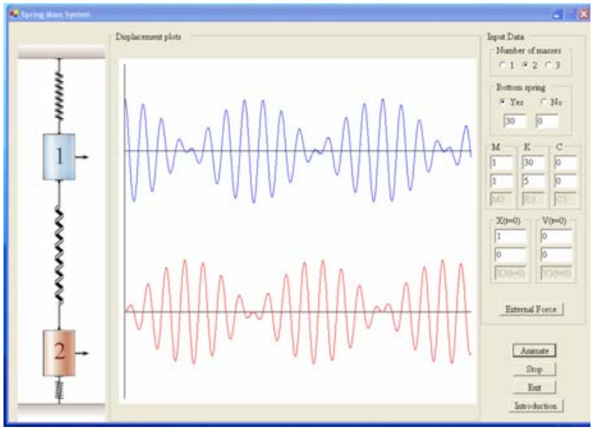

Figure 4. A 2 dof beat phenomenom

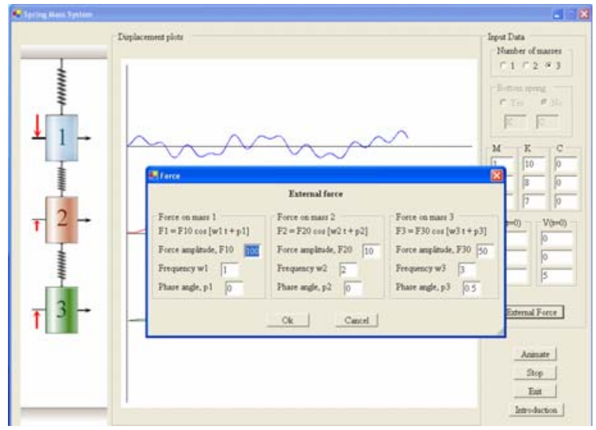

Figure 5. Specification of external forces

3. Transverse Vibration of Uniform Beams

This module allows the specification of the following classical boundary conditions for the transverse vibration of a uniform beam: free-free, fixed-free, fixed-fixed, pinned-free, fixed-pinned, and pinned-pinned. Once the user has selected the boundary conditions, any one of the first four modes of vibration may then be selected, and an animation is shown (Figure 6). A sliding control at the bottom of the screen allows the user to vary the speed of the animation as well as the maximum deflection. The natural frequency is indicated.

In addition to the classical boundary conditions listed above, the user may also choose from a free, pinned, or fixed left condition, and then specify a rigid body for the right end. In this case, the beam and end-mass properties are all selectable. See Figure 7.

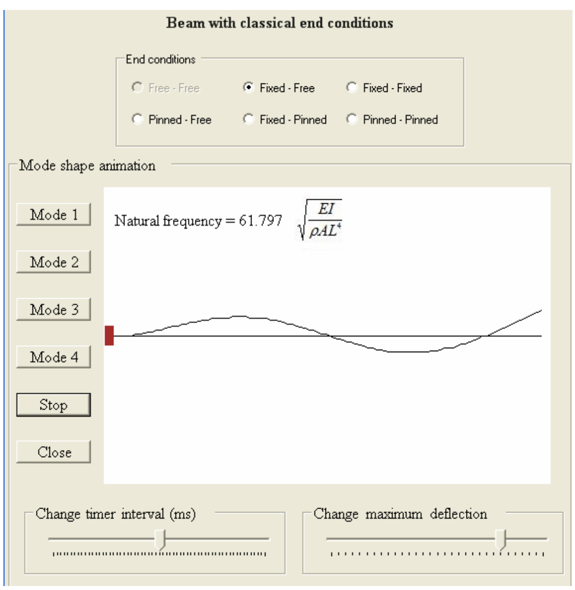

Figure 6. Transverse beam vibration

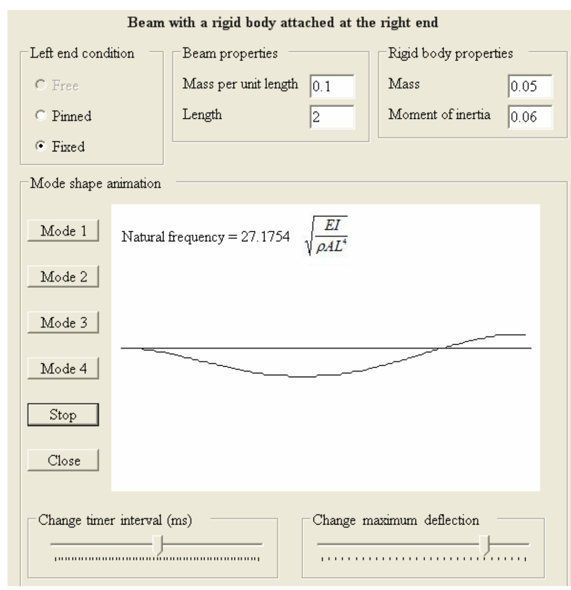

Figure 7. Beam with end mass

STUDENT RESPONSE

This software was placed online during the first semester (Fall 2006) of use in the senior–level ESM vibrations class, and it was also occasionally used in class by the instructor as part of the lecture. The students were requested, but not required, to use the software at home in order to enhance their appreciation for changes in the motion conditions. An optional end-of-semester questionnaire was circulated to approximately 25 students in the class. Thirteen students responded to questions involving the good and bad aspects of the software and the total number of hours that the software was used outside class. Some selected comments, with the total number of hours that the software was used by that student shown in parentheses:

1. "Helps to easily visualize what is happening in vibrations situations. Easy to make changes to those situations." (2 hours)

2. "Gives good visual understanding of what the system is going through. Helped out a lot in the beginning of the semester when I had no idea what was going on and was completely new to the whole subject." (4 hours)

3. "It allows you to better visualize the actual systems." (4 hours)

4. "It was nice to have to verify my own work and/or better elucidate the theory presented in class." (6 hours)

5. "It has a nice user interface and it was not difficult to figure out how to use it." (1 hour)

Following is a comparison of the final grade received in the course along with the average number of hours that the software was used by the students receiving that grade:

A: 3.0 hours	C: 2.25 hours	F: (No responses)
B: 0.7 hours	D: (No responses)	

There appears to be little, if any, correlation of the letter grade with the amount of use of the software.

CONCLUDING REMARKS

Animation software for critical areas of the standard senior or first-graduate-level vibrations course has been presented. The student comments from the initial semester of use have been very positive, but there was no clear relationship between usage and the final course grade. The future plans are to continue to expand and refine, with particular attention being paid to student feedback. One definite change is that the instructor will make the use of this software mandatory – especially in conjunction with conventional textbook-based homework problems.

REFERENCES

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