AC 2010-2147: EFFECTIVE USE OF SCREENCASTING SOFTWARE IN ENGINEERING COURSES

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Effective Use of Screencasting Software in Engineering Courses

Abstract

This paper overviews several situations in which screencasts were developed using screen capturing software to enhance the learning experience in engineering courses. This software allows an engineering instructor with no background in producing training videos to easily produce computer-based videos customized for teaching specific topics. It can be effectively used to provide students instruction outside class in situations in which standard in-class lectures would not be efficient or effective. The particular software package used in this work was Camtasia Studio. Some discussion of video file sizes is included in this work.

In this paper, examples are provided in which screen capturing software was used to produce training videos for students on how to use various features in software tools such as MATLAB and ANSYS. Teaching use of software in a lecture format in class is often not particularly effective. Also, writing tutorial documents for student use of software presents some difficulties, even when great care is taken to precisely word instructions. It is difficult to write a tutorial without inadvertently including instructions that are subject to misinterpretation. Often, when a student who is a new user of some software misinterprets an instruction in a tutorial, it can produce a lot of frustration. However, using screen casting software, it is easy to produce training videos that capture the action on the screen, along with audio explanations, and new student users can easily follow the tutorial examples with few chances of misunderstanding, because they see the tasks exactly as they need to be performed on the video. While they watch the video, they can follow along on the same computer and complete the same steps using the software that is the subject of the video. Students can easily halt the video while they complete a task using the software, then restart, or rewind, as needed. Engineering simulation software continues to take on a more important role for practicing engineers. But, it is a challenge in standard engineering courses to incorporate use of the software in classes while still having adequate time to teach the primary topic of the course, such as vibrations or controls. Screencasts are very beneficial in helping students quickly learn to use various software tools with minimal frustration.

Another area discussed in the paper in which screen capturing software has been advantageous is the creation of videos in which example problems are solved, with audio explanations. Students often ask that more example solutions be provided in their courses. However, lecture time is limited in courses. Certainly, example solutions can be made available for students to review outside of class. But, using screencasts, the students can watch the progression of the example solutions while listening to recorded explanatory audio comments, and this provides advantages in limiting misunderstandings.

Another topic discussed is use of screencasts to allow students in a distance learning environment to observe laboratory demonstrations.

Background

Screen capturing software, such as Camtasia Studio[1], supplied by TechSmith Corporation, is a useful tool for easily creating video recordings using a standard tablet pc. All activity on the computer desktop can be recorded and synchronized with recorded audio. The software includes advanced editing features that allow a great deal of flexibility. In producing a video, recorded segments can easily be deleted, and other segments can be inserted at any desired time point. Use of the software does not require training.

While there are a number of other software applications for screencasting, some less expensive and others more expensive, we settled on Camtasia for implementation in our courses. In a brief review of literature, we found numerous efforts have been reported regarding integrating use of screen capturing in engineering education. One example is the paper by Campbell[2] which overviews use of commercially-available training videos on MATLAB, Mathcad, and Maple software in an engineering program. Jackson, et al[3], discuss use of Camtasia in developing instructional materials for a Six Sigma training program. Brown, et al[4], discuss a programming class in which lecture materials were provided to the students in the form of Camtasia videos.

Doering and Mu[5] used Camtasia in development of a repository of solved circuits problems to augment a standard sophomore-level circuits course. Gao, et al[6], discuss the development of an on-line construction management course that included use of Camtasia for recording lecture material. Class-Morales, et al[7], used Camtasia in developing a general instruction program for use of Autodesk Inventor mechanical analysis and design software. This effort was targeted at supplementing material in a number of mechanical design courses. Pferdehirt, et al[8], used Camtasia in developing weekly 15-30 minute recordings provided on-line as part of the course material for a graduate-level Project Management course in a Master of Engineering in Professional Practice (MEPP) program. Pagliari, et al[9], used Camtasia in an on-line Technical Presentations class. The authors state that lectures were created in Camtasia to teach students to use another software product, Microsoft Producer. The students then created their own training presentations using Microsoft Producer. Shearman, et al[10], describe a large set of modules consisting of screencast videos produced in Camtasia for a music synthesis and audio signal processing course. The videos have been deployed and are available to the public. Biswas[11] reported on use of Camtasia to record each live lecture in a circuits course. The lecture videos were then made available to the students after class for review.

Other examples of use of screen casting software in engineering education can be found. This paper adds further discussion on use of screencasts for a range of purposes. The examples provided here are from courses in the department of mechanical engineering at the University of Kentucky (U.K.). There are several situations in this department in which screen capturing software has been helpful. Some use is in distance learning courses taught via Interactive Television (ITV). In a typical ITV course, there are students receiving the lectures

simultaneously on two campuses. The U.K. main campus is located in Lexington, and the department also offers four-year bachelor's degrees at its extended campus program in Paducah, KY. Some courses are taught via ITV with students simultaneously taking the course in Lexington and Paducah. Also, there is a joint mechanical engineering program offered by Western Kentucky University (W.K.U) and U.K. Students in this program are based at the W.K.U. campus in Bowling Green, KY, and they take some courses via ITV from U.K. faculty based in Lexington and Paducah. Each semester, there are usually some differences in the academic calendars for the three campuses. The ability to easily record a lecture for students when one campus does not meet on a particular day has been valuable. For example, in a course that has students in Paducah and Lexington, if spring break falls on a different week on the two campuses, then students who are on break when a lecture is delivered can view the recording after their break. Additional valuable uses for screencasts involve instruction on software use that is supplemental to the standard lecture material, and also solution of example problems to be viewed by students outside regular class time. Below, some selected and varied experiences using screen casting software in U.K. mechanical engineering courses are described. The software has been used beyond the specific examples provided, but these examples are selected to provide an overview of how its use can be advantageous in a range of circumstances.

Mechanical Vibrations

This course is taught during each fall semester. It is taught via ITV with students in Paducah and Lexington receiving the lectures simultaneously. Also, there is a separate section of students based at W.K.U. receiving lectures delivered from Paducah. When the lectures are delivered to W.K.U., there are no students at any other campus simultaneously receiving the lectures. As mentioned above, the Camtasia software has been helpful in this course in situations when, for example, the Lexington campus was on a break but the Paducah campus was in session. In such a case, the lecture could be delivered as usual to the Paducah students, with the lecture recorded and posted for viewing by the Lexington students on Blackboard. In this course, much of the lecture material is provided to the students in advance of each class in PowerPoint files. The material in PowerPoint is supplemented with handwritten notes using a stylus on a tablet PC. In cases where a lecture is recorded, all screen activity is recorded, including handwritten notations. Audio is included using a standard lapel microphone connected to the PC.

Another valuable use of screencasts in this course has involved material supplemental to the standard lecture material aimed at aiding students in software use for completing assignments. Use of computing software, such as MATLAB, can be very helpful for the students in solving many vibrations problems. This is a dual-level course including both graduate students and undergraduate students, so there are varying backgrounds for the students. Some have had extensive use of MATLAB, and some have had little or no experience with the software. It is very difficult to complete any type of dynamic analysis for a system larger than two degrees-of-freedom (DOF) without the aid of a software tool, such as MATLAB. It does not seem to be very effective, however, to provide instruction on use of such software in a standard lecture

format. A hands-on approach seems to work much better. A screencast on the software use can be viewed outside class, and the student can open MATLAB, and perform tasks discussed in the video while they watch the video. And, they have the option to stop and rewind the video, as needed.

An example homework assignment for which MATLAB use was recommended is provided in the Appendix. This assignment requires analysis of a three DOF system. To assist the students in completing this assignment, a screencast was produced in which the steps required to analyze a different, but similar system, were completed using MATLAB. The example system discussed in the video was a simpler two DOF system. After watching the video, the students could adapt the same approach to analysis of the three dof system in their homework assignment.

Figure 1 shows a screen capture that illustrates the inclusion of handwritten material in the video, written as the video was recorded using a stylus and Microsoft Windows Journal software on a tablet PC. This written material was saved in PDF format and provided to the students with the video. Figure 2 shows another screen capture from the same video in which a MATLAB "m-file" is being discussed, which was programmed to complete the analysis calculations and plots. A MATLAB m-file is a macro, or program. MATLAB allows for standard structured programming features to be included in an m-file, such as loops and *if-then-else* logic. It seems much easier to explain these programming features using a video rather than with a static tutorial or a standard classroom lecture. Figure 3 is another screen capture from the video showing some results plots generated in MATLAB for the example analysis.

A similar approach has been used in this course to instruct the students on how to use the ANSYS finite element software package to perform a vibration analysis on a beam. While this course does not have, as a prerequisite, background in finite element analysis, it seems beneficial for the students to gain some exposure to this widely-used computational method of solving vibrations problems. It is not practical, in the time available in this class, to give the students a broad overview of complex finite element software, such as ANSYS. But, for a specific type of ANSYS analysis, a training video developed with screen capturing software provides the students enough information to complete the analysis tasks. This exposure to ANSYS is useful in providing the students a glimpse into how the types of calculations they have applied to analyze simple lumped mass models can be extended to models of practical systems.

Gas Dynamics

Gas Dynamics is a dual-level (undergraduate/graduate) course regularly offered via ITV from Paducah to Lexington at the University of Kentucky. This course covers all of the classical topics in compressible flow from one dimensional flow with heat transfer to the method of characteristics for two dimensional steady supersonic flow. As is often found in other courses, students in the gas dynamics class would like to see more example problems worked in-class.

To supplement the example problems covered during regular class time, four additional example problems recorded using Camtasia Studio were used in fall semester 2009. Starting from these four recorded example problems it is planned to add more recorded example problems in the next offering of gas dynamics. A survey was used to elicit student feedback for assessment of the video effectiveness and to indicate areas where improvements can be made in the content and quality of the recorded example problems. The results of the survey are discussed in a later section along with a discussion on an improved survey to be used in each course covered in this paper in the future.

The example problems were recorded from a tablet PC using Camtasia Studio's ability to record PowerPoint. A camera/microphone combination was used to record the audio as the example problems were solved step-by-step. However, to reduce the overall size of the recordings, no video of the instructor was used.

Each example had a typed problem statement or detailed schematic diagram with all the given data as the starting point. Problem solutions started with a discussion of the problem statement and a verbal outline of how the problem would be solved. Since the tablet PC allows one to write on the PowerPoint slides with a stylus while in slide show, the example problems were solved much like writing on a whiteboard or overhead projector in a classroom setting. The simultaneously recorded audio provided verbal comments while the problem was being solved.

Before recording the example problems an outline was made of the presentation sequence. From the outline, the example problem was recorded in multiple parts; i.e., the example was not recorded in one continuous stream, but divided up into segments with each segment recorded separately. After completing the recording of the individual sections of the example problem, the sections were reviewed for content. This permitted rerecording of a specific section if any type of alteration was deemed necessary. Once the review of each distinct section was completed, the separate sections were concatenated into a single video recording using the editing features available in Camtasia Studio.

Two of the examples recorded were classical problems found in most textbooks. One was the development of the Rayleigh pitot-tube relation and its use to determine the test section velocity in a supersonic wind tunnel. The second was the regular reflection of an oblique shock wave from a wall.

The other two problems supplemented the examples found in the textbook used for this course. The solution for one dimensional flow with friction and a normal shock wave was presented for one of the problems. This illustrated the solution of a problem with multiple compressible flow features. The other example problem considered was the solution of a normal shock wave for a thermally perfect gas (variable specific heats). Many textbook problems in compressible flow assume the specific heats for the gas are constant. For constant specific heats the governing equations simplify to nice algebraic equations that can be easily solved and used illustrate

important features of compressible flow. This example introduced more state relations to consider, plus simultaneous solution of the governing equations numerically thereby illustrating a more accurate solution that can be easily obtained using commercial software readily available to engineering students.

All the example problem videos were posted on the University of Kentucky, College of Engineering web site. Students gained access through a link on the instructor's personal web page. In this initial offering, the link to the videos was password protected. After entering the password the students selected an example problem to view. The videos were in FLV format and directly viewable from the web site. The video viewer had the usual start-pause-stop and audio level options along with a slider bar that could be used to move to user selected parts of the video. Hence, the students could repeat any portion of the recording as desired.

Capstone Design and Other Courses

As discussed above, a primary use of screen capturing software is to record supplemental material that may not be presented in class. It is also helpful in providing student access to material for a class presentation that was missed due to absence. This has been used for recording a classroom lecture, and posting the screencast on Blackboard or other websites accessible to students. In cases where copyright issues might arise, a password protected site, or a site such as Blackboard limited to enrolled students, is appropriate. Even if the students were in class, it is often helpful to view a given lecture, or portion of a lecture, after the class session or for exam review. The capability can also be used when a faculty member needs to miss an occasional class due to travel or other commitments.

In U.K. distance courses, recording approaches are used integral to the distance delivery technology. While these recordings are valuable, and require no instructor actions, screen capturing software offers several advantages: (1) ability to edit recordings,; (2) ability to provide the recordings in a variety of formats; (3) ability to easily provide a table of contents by slide caption, so students can easily navigate to a particular point in the material; and (4) ability to provide a higher resolution image than might be provided otherwise.

Another web-based resource is that of web-conferencing, such as Adobe Connect, Webex, or similar approaches. This has been used for office hours with distance students, and for collaborative design efforts in capstone. Student teams need to interact with industry sponsors, and web-conferencing allows this to be accomplished with less travel – sharing of visual material such as Powerpoint or CAD drawings makes the interaction much better than a basic phone conference. Screen capturing software offers the ability to develop a short training video showing how to make effective use of web-conferencing. This resource is then available whenever students or participants need it.

File Size and Video Format

The file size of the videos produced by Camtasia Studio was considered. The study was conducted using a 17 minute example recorded for the gas dynamics course. The original screen capture of the PowerPoint slides with audio overlay was 50 Mb. A number of different video file formats were created from the recorded file. The formats considered were Windows Media Video (WMV), Audio Video Interleave (AVI), and iTunes Video Files (M4V). In all cases default settings were used to produce the video in the desired output format. Table 1 presents the file sizes.

Except for the AVI video format, the final video produced was approximately one-fifth the size of the original screen captured file. However, no formal evaluation was conducted of the video quality for the different video formats.

Table 1. File sizes as a function of video format for a 17 minute recording

Video Format	File Size	FLV File Size (after conversion)
Original Screen Capture	50 Mb	-
Windows Media Video (WMV)	10.6 Mb	19.2 Mb
Audio Video Interleave (AVI)	51.4 Mb	19.7 Mb
iTunes Video (M4V)	19 Mb	17.5 Mb

Each video produced was converted to Flash Video (FLV) format. The Flash Video file sizes were all similar, as shown in Table 1, and there was no significant file size advantage for any particular format. For the gas dynamics example videos, which were accessible and viewed by the students from a web site, the AVI format was produced from the original screen capture file and then converted to Flash Video. From student feedback the video and audio quality was acceptable.

With the popularity and wide spread availability of handheld electronic devices, file sizes can be important when considering downloadable content. Table 1 can provide some guidance on the impact of the different video formats on file size.

Assessment

To get feedback on the usefulness of the recorded example problems in the Gas Dynamics course, a student survey was used. In the fall 2009 offering of Gas Dynamics seven students were enrolled in the course. Six students returned the surveys with five students answering all the questions. This is a relatively small number for statistical purposes. However, it does give some indications of the impact of the recorded example problems and some direction on where future effort should be devoted. Since this is an ongoing process, additional student feedback

will be gathered in future offerings of the course. This includes the development of an improved survey.

The questions used in the survey are given below.

1. Did you watch any of the videos?
        Yes   No

2. Did you watch all of the videos?
        Yes   No

3. Do you feel the videos helped you understand the course material covered in the videos better? (1 = Not at all, 5 = Much better)
              1   2   3   4   5

4. Do you think the videos should be expanded to include more examples?
        Yes   No
   If yes, list what you would like to see included:

5. Do you think more in-depth lecture topics, for example the viscous solution of the flow through a normal shock, could be covered using web videos?
        Yes   No
        Explain:

6. Was the audio quality acceptable?
        Yes   No

7. Was the video quality acceptable?
        Yes   No

The survey results indicated the following:

1. Five out of the six responding students watched at least one video.
2. Three out of the six responding students watched all the videos.
3. The students indicated the material in the videos helped with their understanding of the course material (average rating of 4.2 on survey question 3).
4. Four out of five responding students suggested the videos should be expanded to include more example problems.
5. Four out of five responding students were in favor of recorded lecture topics.
6. All the responding students indicated the audio and video quality was acceptable.

Conclusions that can be drawn from the survey results are:

1. The internet bandwidth was sufficient enough that video and audio quality was not compromised. While this should be continuously monitored, it does indicate that web based viewing of the videos is viable.
2. Recorded videos that supplement textbook and classroom example problems are viewed as being helpful, and the number of example problems should be increased.
3. Special topics can be recorded and used to expand on material covered in lectures.

Future Related Plans

Use of screencasts to date in the department has been for various purposes by several faculty. More in-depth assessment of the educational value of its use, based on student feedback and possibly other measures, would be helpful in development of best practices guidelines. The software will again be used in the spring semester of 2010, likely in a number of courses. Two ITV courses, in particular, in which its use is planned are the dual-level courses, "Turbomachinery" and "Computational Techniques in Mechanical System Analysis".

In the Turbomachinery course, an approach similar to that outlined above for the Gas Dynamics course is planned in which the students will have available screencasts in which numerous example problems are solved. These can be viewed outside of class as supplemental material to augment the lectures. The computational techniques class involves extensive use of ANSYS and MATLAB. More use of screencasts will be made in this course in production of training videos for use of these software packages, with the video content customized for use with the course lecture material. Less in-class lecture time will be devoted specifically to software use instruction than in past course offerings, because the training video approach appears to be more effective.

In the fall of 2010, it is planned that the mechanical vibrations course will again be offered via distance learning. This class includes some lab-type demonstrations. These require the instructor to travel to the remote site on demonstration days, because the ITV technology does not lend itself well to these types of activities. The demos include things such as oscillations of a 2-DOF spring/mass system and of a flexible cantilevered beam. It is planned that demonstration videos will be recorded with a camera, and the video files will be imported to Camtasia. Camtasia has slow-motion capability, and it is expected that the demonstrations can be enhanced using this software, and it may not be necessary for the instructor to travel to the remote site for the demos.To better determine best practices in use of this tool in an educational setting, it is planned that in at least the two courses to be taught in spring 2010, Turbomachinery and the computational techniques course, a uniform survey will be used. During the course of the semester, an improved survey will be developed.

Summary and Conclusions

Screen capturing software offers a great deal of flexibility for a range of purposes in engineering education. It requires little or no training to use. In the future, it is expected that it can be used for additional purposes beyond the specific ones outlined in this paper. For example, recording of special topic lectures that are based on student interest that may be beyond what can be

covered in a normal classroom setting or time frame. More assessment data is needed to better determine optimal methods for utilizing this tool.

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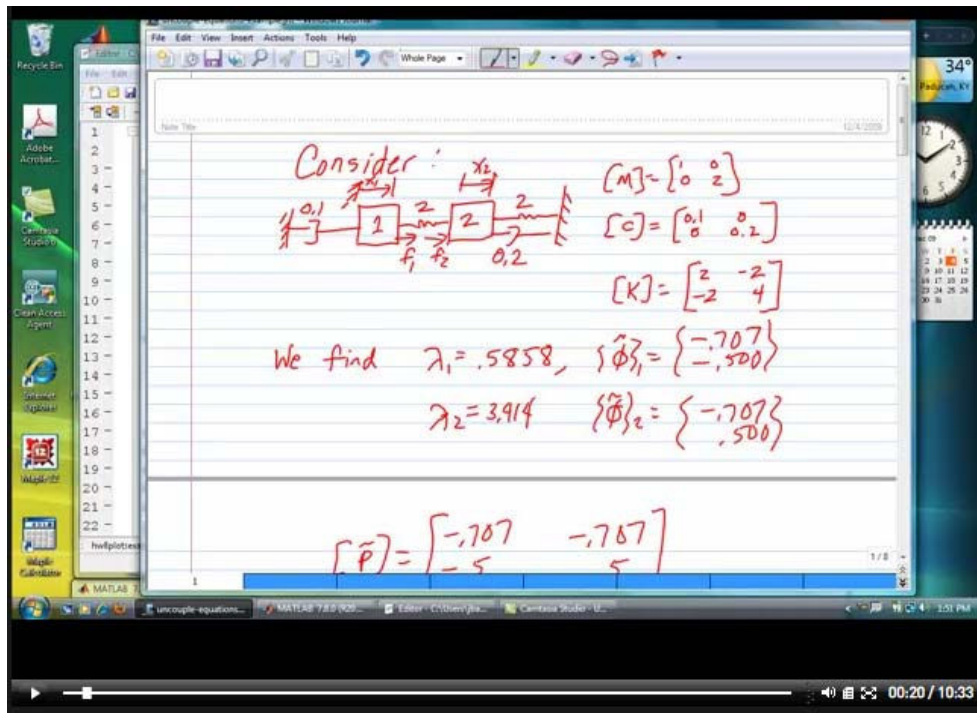[13]ANSYS, Copyright 2009, SAS IP, Inc., http://www.ansys.com

Figure 1: Screen capture of a video from a vibrations class showing an example problem set-up using a stylus and Microsoft Windows Journal software on a tablet pc.
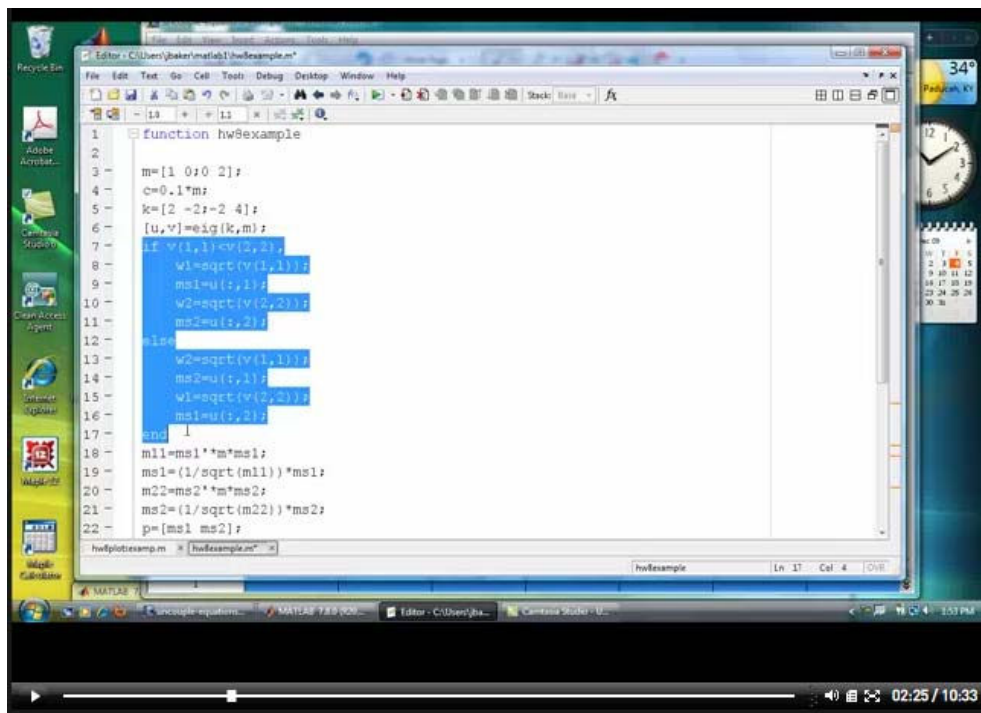

Figure 2: Screen capture of a video from a vibrations class showing a discussion of how to write a MATLAB "m-file". Here an *if-then-else* sequence is highlighted for discussion.
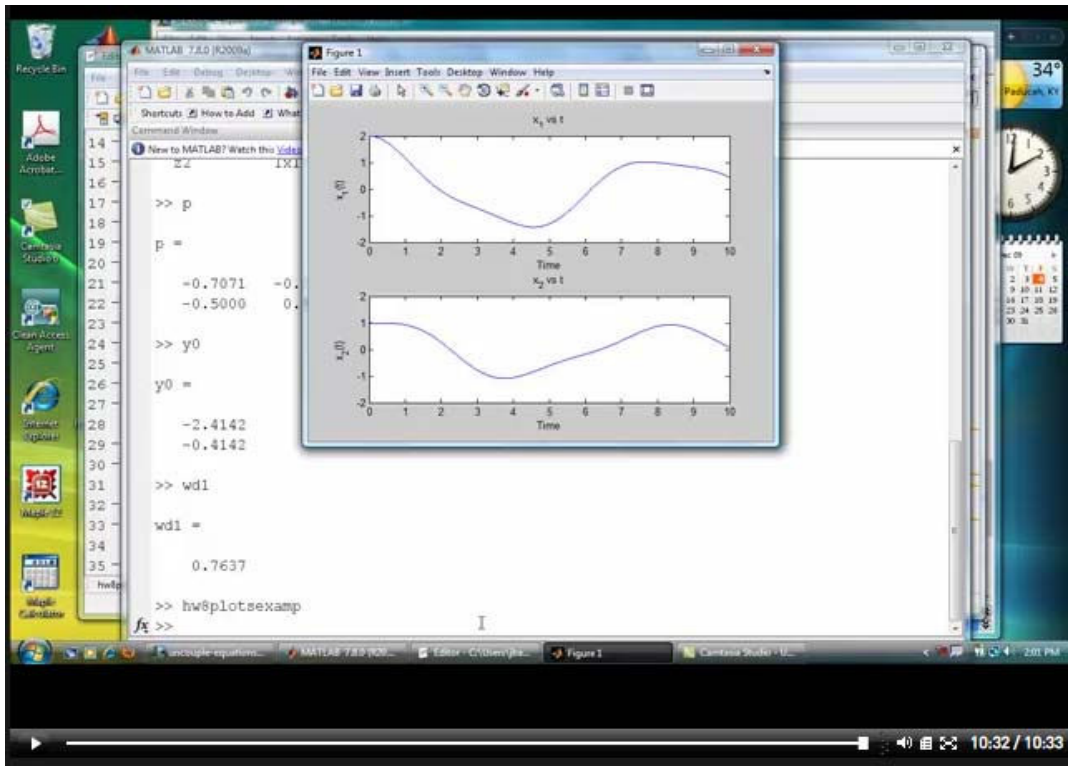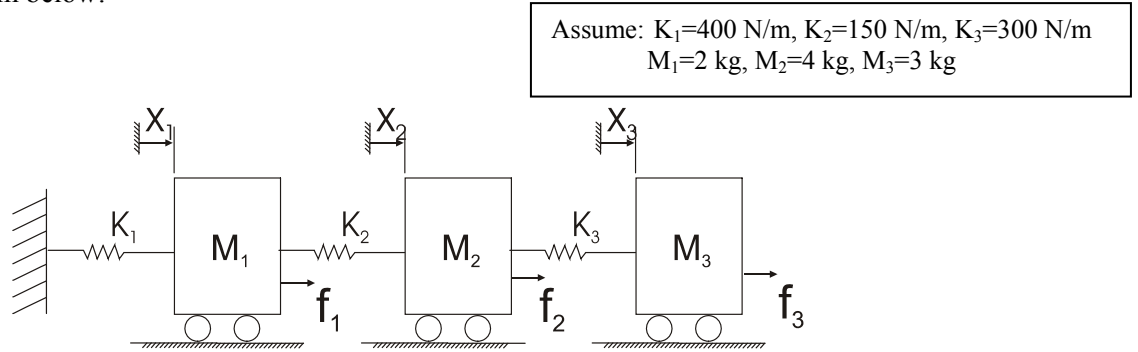
Figure 3: Screen capture of a video from a vibrations class showing generation of results plots in MATLAB.

Appendix

Consider the system below:

Assume: K_1=400 N/m, K_2=150 N/m, K_3=300 N/m
M_1=2 kg, M_2=4 kg, M_3=3 kg

Assume there is damping in the system with a damping matrix, [C], given by [C]=0.001 [K], where [K] is the stiffness matrix.

1. Calculate the orthonormal modes: $\{\widetilde{\phi}\}_1, \{\widetilde{\phi}\}_2, \{\widetilde{\phi}\}_3$. You will probably want to use MATLAB.

2. Write the uncoupled system equations in terms of modal coordinates, {y}, using the substitution: $\{x\}=[\widetilde{P}]\{y\}$. Note that the columns of $[\widetilde{P}]$ are the orthonormal modes: $\{\widetilde{\phi}\}_1, \{\widetilde{\phi}\}_2, \{\widetilde{\phi}\}_3$. Leave the equations in terms of the unknown forces f_1, f_2, and f_3.

3. List the effective damping ratio for mode 1 (ζ_1), the effective damping ratio for mode 2 (ζ_2), and the effective damping ratio for mode 3 (ζ_3). Also, list the damped frequencies of oscillation for each mode: $(\omega_d)_1$, $(\omega_d)_2$, and $(\omega_d)_3$. You can determine this information directly from your uncoupled equations in Problem 2.

4. Using your equations in Problem 2, assume the masses are initially at rest, the forces f_1, f_2, and f_3 all equal zero, and the initial displacements are $x_1(0)$=1 m, $x_2(0)$=1.25 m, and $x_3(0)$=-1.50 m. Calculate an expression for each of the responses, $x_1(t)$, $x_2(t)$, and $x_3(t)$. Clearly indicate the component of each response due to mode 1, the component due to mode 2, and the component due to mode 3. Based on these results, would one of the modes dominate the responses? If so, which mode? Plot $x_1(t)$, $x_2(t)$, and $x_3(t)$ for 0≤t≤10 seconds.

5. Repeat problem 4, but assume $x_1(0)$=1 m, $x_2(0)$=0 m, and $x_3(0)$=1 m.

6. Let f_1=f_2=0 and f_3=U(t) N (unit step). Assume all initial displacements and velocities are zero. Calculate $x_3(t)$ for this case using your equations from Problem 2. Plot $x_3(t)$ for 0≤t≤10 seconds, then plot only the component of $x_3(t)$ due to mode 1 only.