Using Multimedia in Teaching Dynamics

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Abstract

This paper discusses needs, methods, and benefits of using multimedia in teaching dynamics in engineering technology.

Introduction

In the author's experience, engineering dynamics is a difficult course for students to study and for instructors to teach. The course is rather analytical and has little or no laboratory work. Typically engineering technology students would like to relate the concepts in a course to their work and life in order to learn well. However, probably because dynamics textbooks are written by scholars in theoretical mechanics, some descriptions in these books may not have clear engineering sense to students. For example, it says in dynamics textbooks that "in the case of a perfectly elastic impact, the total energy of the two particles, as well as their total momentum, is conserved." If mass A has velocity v_A and v_A' before and after a perfectly elastic impact and mass B has velocity v_B and v_B' before and after the impact, then

$$\frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 = \frac{1}{2}m_A(v_A')^2 + \frac{1}{2}m_B(v_B')^2 \qquad\qquad m_A v_A + m_B v_B = m_A v_A' + m_B v_B'$$

While the statement can be completely sound in the mechanics world, it is often puzzling to engineering technology students. For example, in reality after a ball is dropped to the ground, it will not rebound to the same height even without air resistance, which means neither the total energy nor the total momentum is conserved during the impact. Would it necessarily mean some non-elastic deformation, or plastic yielding, has occurred to the ball or the ground?

Here is another example to illustrate some difficulty in learning dynamics by engineering technology students. It is a homework problem in the textbook the author uses. It says that "The suitcase A has been propped up against one end of a luggage carrier B and is prevented from sliding down by other luggage. When the luggage is unloaded and the last heavy trunk is removed from the carrier, the suitcase is free to slide down, causing the carrier to move to the left. Neglecting friction, determine..."

While the no-friction assumption makes the problem simpler, it does not sound proper. It is friction that prevents the suitcase A from sliding down until the last trunk is removed.

Part of my experience in teaching dynamics is that at times I need to translate some terms and examples from scientific language to engineering language, so that students can better relate the material to their work, and feel the subject useful and interesting. Recently I have started using multimedia to describe object motion.

Why should we develop our own multimedia kinematic models?

Some dynamics textbooks today include computer disks or CD's to use computer graphics simulation to illustrate the motion of some mechanical devices such as the Geneva mechanism. While those multimedia materials are very helpful, they have the following limitations:
1. Only selected example problems are illustrated. Homework problems are basically not included.
2. Included on the CD is a multimedia viewer only, which limits how the animation can be manipulated.
3. Students are not involved in development of the models. Hence they do not learn the techniques to develop models of their own.
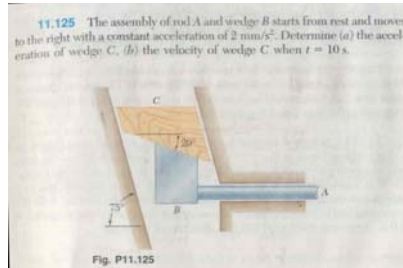
According to the author's experience, developing our own multimedia models for the dynamics course has the following benefits:
1. Through the process of creating and using dynamics models of mechanisms in the book, students will hopefully be able to use multimedia dynamic modeling technique in their work.
2. During the process of creating a dynamic solid model, students will need to add some design details to the original dynamic sketch and therefore gain more engineering design knowledge and experience.
3. Constructing dynamic solid models of given problems often presents challenges to students beyond what they have learned in the CAD course. They will gain more knowledge and experience of computer-aided solid design.

Example

In the following, we will present an example of creating and using a multimedia dynamic solid model. Specific construction steps will not be listed because they well depend on the CAD system. Interested readers are welcome to contact the author for construction details.
- The original model, shown below, is a homework problem in our dynamics textbook.

11.125 The assembly of rod *A* and wedge *B* starts from rest and moves to the right with a constant acceleration of 2 mm/s². Determine (*a*) the acceleration of wedge *C*, (*b*) the velocity of wedge *C* when *t* = 10 s.

Fig. P11.125

- We used Unigraphics Solid Edge, Version 9, the academic edition to create a solid model.
    - Four solid parts, the wedge, the wedge guide, the slider, and the slider guide were created.
    - Please note the design of the wedge and the wedge guide. Some design details were added.
    - The four parts were then assembled with their respective relations.
    - The slider guide is completely restrained with respect to the wedge guide.
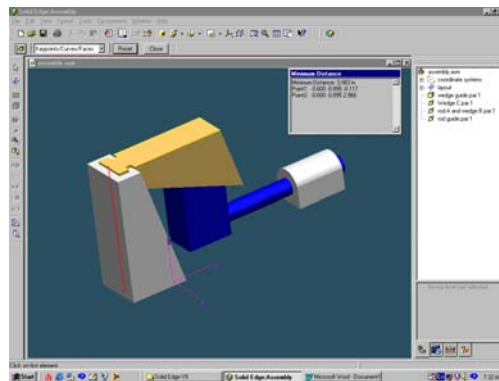
- The assembly can be sectioned.
- The view angle can be changed.
- Dimensions and distances can be measured.
- The slider can be moved left and right by the mouse for simulating mechanism movement.

- The model then was studied in Motion, one of the environments of Solid Edge Assembly.
    - In this environment an animation model was developed.
    - The animation model
        - Can be played on the screen.
        - Can be saved in an AVI file.
        - Can be saved in a VRML (Virtual Reality Modeling Language, a format for describing interactive 3-D multimedia on the Internet) file.
    - Shown below is the model in the Motion environment.
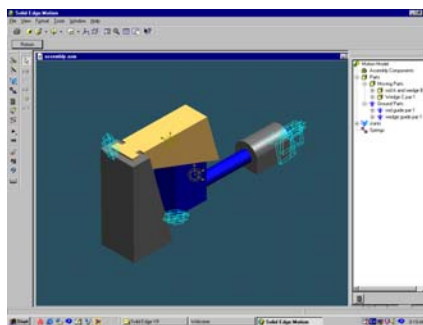
- The Solid Edge model was then studied in MSC-visualNastran Desktop 4D.
  - From inside Solid Edge, MSC-visualNastran Desktop 4D was launched and the Solid Edge model was automatically imported into visualNastran.
  - As shown in the pictures shown below, input acceleration of the slider can be adjusted on the input meter and the corresponding output acceleration of the wedge can be seen on the graphical output or on the digital output. The acceleration value shown here is the same as the analytical result shown in the textbook.
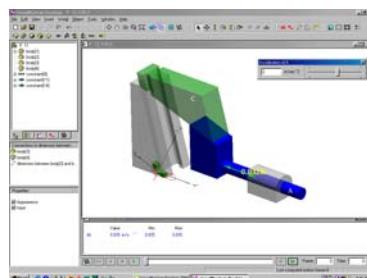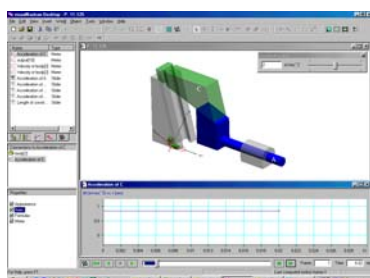
- VisualNastran can also create AVI files and VRML files.
  - While neither AVI files nor VRML files can be inserted into this word-processing document, they are available on my web-site http://users.ipfw.edu/liang/dynamics.htm.
  - To view VRML models on the web, the following are needed:
    - A proper browser such as Microsoft Internet Explorer Version 5.50.
    - A proper plug-in in the computer.
  - Please try each button of the VRML viewer to explore its interactive 3-D capabilities.

Bibliography

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4. Ferdinand P. Beer and E. Russell Johnson Jr., "Vector Mechanics for Engineers," sixth edition, McGraw-Hill, 1997.

Biography

ZHONGMING (WILSON) LIANG is an associate professor of mechanical engineering technology at Purdue University Fort Wayne campus. He received his BS and MS in China and a ME from City College of New York. He conducted fruitful doctoral research at Stevens Institute of Technology, New Jersey from 1983 to 1987. His main research interest is in mechanism and machine theory and has published some articles.