

Using Contemporary Tools to Teach Dynamics in Engineering Technology*

RATAN KUMAR AND MITTY PLUMMER

Department of Engineering Technology, University of North Texas, Denton, TX 76203, USA

The following paper illustrates the usage of modern educational tools in teaching dynamics to students of engineering technology. Problems in engineering technology are traditionally skill based rather than theory based. As a result the instructor has to illustrate problems keeping the hands-on approach in mind. One of the best ways to exemplify theory, to meet the above requirements, is the usage of modern educational tools like multimedia, simulation software and visualization techniques. This helps the students to understand the engineering aspect of dynamics from the pure science aspect of the subject matter—a key feature in satisfying our program requirement.

INTRODUCTION

ENGINEERING technology has differentiated itself from engineering education by teaching applied scientific and engineering knowledge and methods combined with technical skills in support of engineering activities [1]. The engineering technologist plays a key role of an implementor rather than that of an inventor, to support engineering functions. As a result, this educational program is designed to be application oriented and builds upon a background of applied mathematics through the concepts and application of calculus. The successful students must be able to discern the components of a system and be able to operate the system to achieve goals established by the engineer. Dynamics is the first real engineering course encountered by the students and it offers the instructors the opportune time to teach the applied aspect of science and engineering. It offers students problems involving a simultaneous mix of mathematics, physics, computer and common sense in a challenging way.

The current text books available in dynamics are mostly prepared for engineering students, and do an excellent job, but the associated rigorous theory makes it an uninteresting academic hurdle for many technological students. Quite often, this theory-oriented approach results in some disparity between text coverage and student comprehension. However when the theory is exemplified with the modern educational teaching media like multimedia, World Wide Web, mathematical software and visualization techniques, the conceptual understanding and visual analysis is enhanced. Dynamics is a subject that depends on geometric and physical perception and every effort should be made to enhance this ability. This makes it an interesting challenge in an exciting area, requiring

creativity and imagination as well as knowledge and systematic thinking.

INSTRUCTIONAL STRATEGY

In order to implement the aforesaid, the following issues were addressed:

- knowledge,
- comprehension,
- application,
- synthesis.

These are four of the six educational objectives covered in Bloom's Taxonomy of Educational Objectives [2]. The two objectives not covered explicitly, according to the authors, when applied to the study of dynamics belongs mostly to the engineering domain. The study of each section was broken down into:

- basic principles and theory (for knowledge),
- problem solving (for comprehension),
- common engineering applications (for application),
- small design problems (for synthesis).

Throughout the course several creative real-world engineering dynamics problems were introduced in the class. They were presented in the form of lecture, multimedia and simulation software. The lecture would basically cover the theory and problem-solving strategies. The objective was to teach students how to approach problems and critically judge the results. In order to solve mathematical problems, stress was laid on using mathematical software and spreadsheets. Homework assignments were mostly computer based and projects were assigned which required usage of simulation software. Some of the problems needed hand calculation but repetitious calculation to see the effect of different variables on the solution was performed by using mathematical

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software. This forced the students to spend more time in understanding the problem and laying out the right mathematical expression and less time in solving various forms of it. Care was taken to pose real-world technical problems which a sophomore student is exposed to. Visualization of the problem and results was afforded through models, pictures, graphs and simulation. The emphasis on understanding the engineering aspect of the problem was best illustrated by giving design problems. The engineering technology students better appreciated this concurrent approach in teaching traditional theory with modern educational tools and using real-world examples most of the time.

A typical 50-minute class lecture was broken down as follows:

- 15 minutes for theory presentation;
- 15 minutes to solve some simple problems relating to the theory,
- 15 minutes for multimedia/simulation presentation;
- 5 minutes to discuss and get feedback from the students.

For example when discussing the introductory section on general motion of a point, the lecture would consist of relationship between position, velocity and acceleration and description of motion in a straight line. This would be followed by the problem-solving session consisting of 2 or 3 problems. The homework assignment typically consisted of five problems, with three requiring solution using traditional techniques and two needing the use of both traditional methods and technical software. The students were aware of the material to be presented beforehand and were encouraged to read it before coming to the class.

SOFTWARE TOOLS

The usage of software tools, as a complementary medium to class-room lecture was heavily relied upon. A variety of software was used for multimedia application, simulation purposes, mathematical computation and spreadsheet analysis. Although some of them required an extra learning time, it was concluded that it was time well spent as the students will be using more of this software in their later classes.

Multimedia.

This technology holds tremendous promise in providing an educationally sound learning mechanism. As has been mentioned by several authors [3], students learn best when acting and reflecting and not by watching and listening. The application of multimedia, through properly co-ordinated lesson design on CD-ROMs, helps immensely in fulfilling the above requirement. The authors think that such CD-ROMs should be added as a new component to the course and complement the textbook, lab activity and lecture. An ideal multimedia software should fit a variety of situations: classroom activity, laboratory or homework and as an additional study guide. Flori *et al.* [4] have done a literature survey on dynamics software available.

For multimedia purposes the authors found the work by Grammol [5] to be best suited for their students. It contains about forty-three creative real-world problems that cover a typical dynamics course. Since we have about 45 classes one problem can be shown in every class and the students can explore it fully in their laboratory hours. Figure 1 shows the main menu for the software program. It consists of ten sections each of which has at least

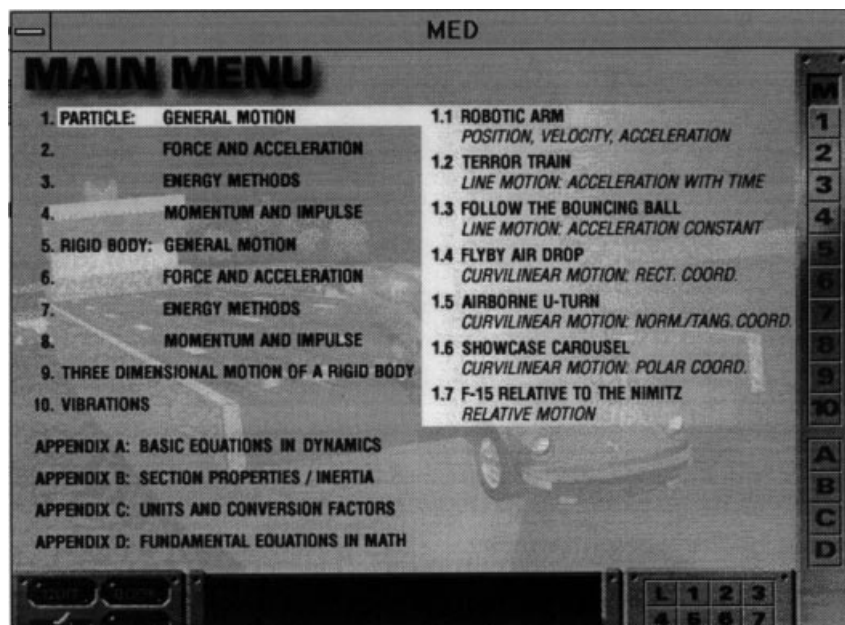


Fig. 1. Main menu for Multimedia Engineering Dynamics by Grammol.

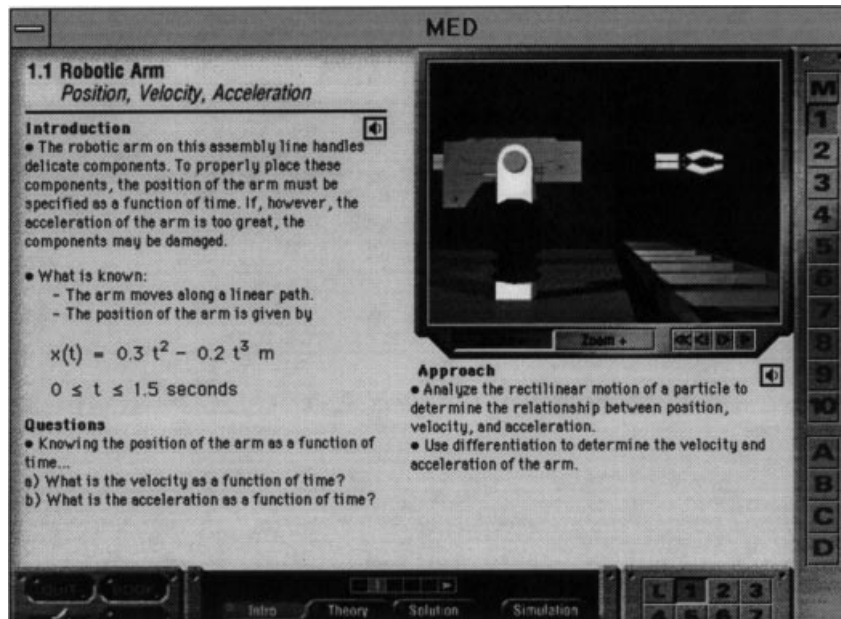


Fig. 2. Grammol's Multimedia software illustrating the robotic arm principle.

two illustrative problems explaining some theory. The problems are presented using text, graphics, animations and audio. Each problem contains a simulation that models it and gives the learner the power to dynamically manipulate physical systems and explore engineering concepts. The simulation is done with *Working model* [6] program from Knowledge Revolution. One of the problems chosen to illustrate straight line motion by an engineering process was that of a robotic arm. Figure 2 shows one of the multimedia screens, from Grammol [5], that was used for class-room demonstration.

Simulation.

Working Model from Knowledge Revolution is fast becoming a popular software tool in educational institution. It is a motion simulation package that allows one to quickly build and analyze dynamic mechanical systems on desktop computers. For class-room instruction, only pre-built models created with this software were used. This was necessary since within the time constraint, we thought it was more important to show the effects of simulation for a particular theory and its associated problem, rather than the students spending time building the simulation interface.

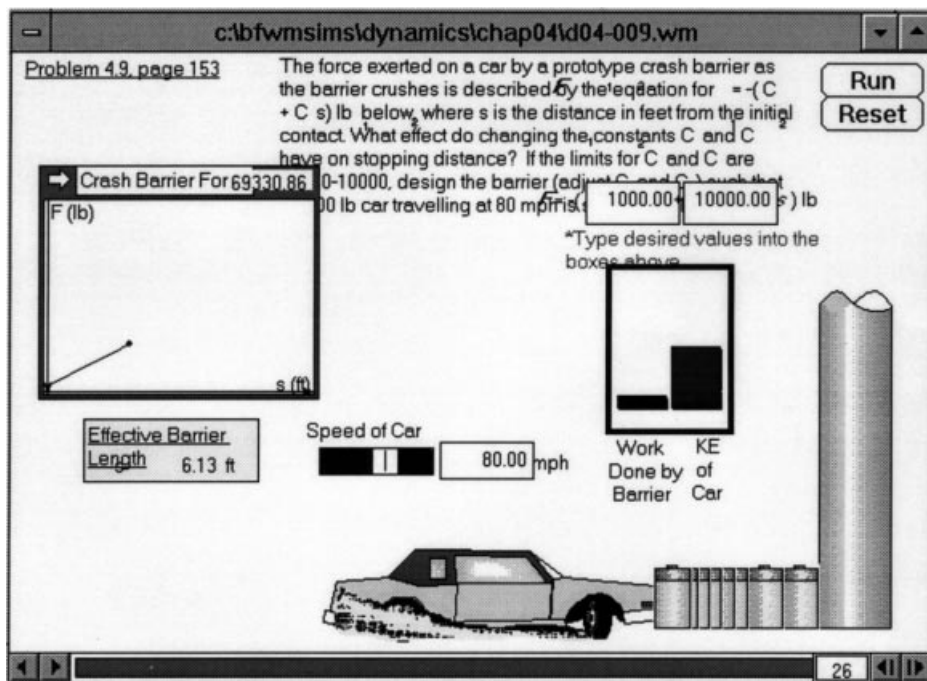


Fig. 3. Simulation exercise by working model for a typical homework.

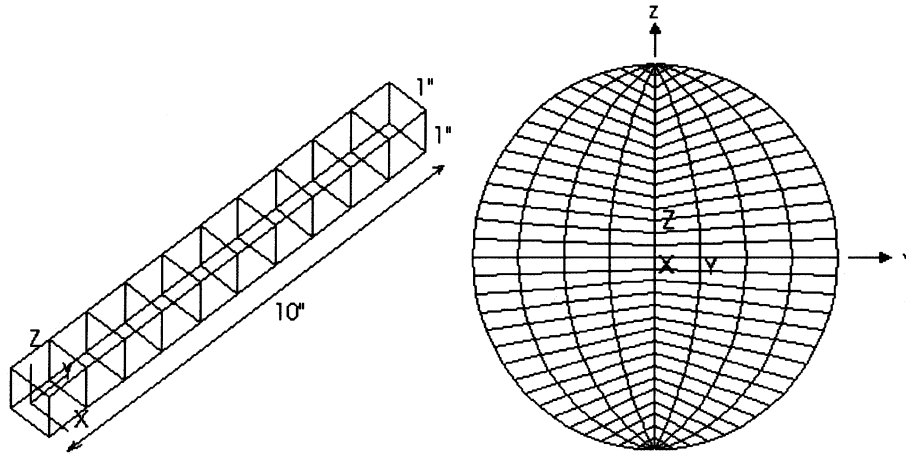


Fig. 4. Determination of weight, center of gravity and mass moment of inertia of a square beam and a circular plate by ALGOR.

Moreover, several pre-built and tested models already exist. Bedford and Fowler [7] have about one hundred problems and examples from their text book, that have been recreated on disk as *Working Model* simulations. They serve as a repository of examples that can be shown to the class and used as homework problems.

Our students learn to build simulation models in their later design classes. Figure 3 shows a problem where the student have to design a barrier to stop a moving car. This example has been taken from Bedford and Fowler's [7] book and serves as a small design type of problem too. Some simulation examples were also shown in Algor [8], a general-purpose finite element package. However its use was very restrictive as some students can get confused with advanced techniques.

Figure 4 shows how finite-element packages can

be used to determine the weight, center of gravity and mass moment of inertia of a square beam and a circular plate. The problem was selected to show how numerical simulation can exactly match a theoretical result. In this case the problem was selected from Beer and Johnson [9]. The above examples were not created by the students but were selected for illustrative purposes from Algor's web page.

Mathematical.

Since we did not want our students to get constrained with mathematical manipulations, but rather learn the subject matter, the use of mathematical software was encouraged. The students had access to some popular software packages like Mathcad [10]. These packages help to put text, graphs, equations and numbers on one

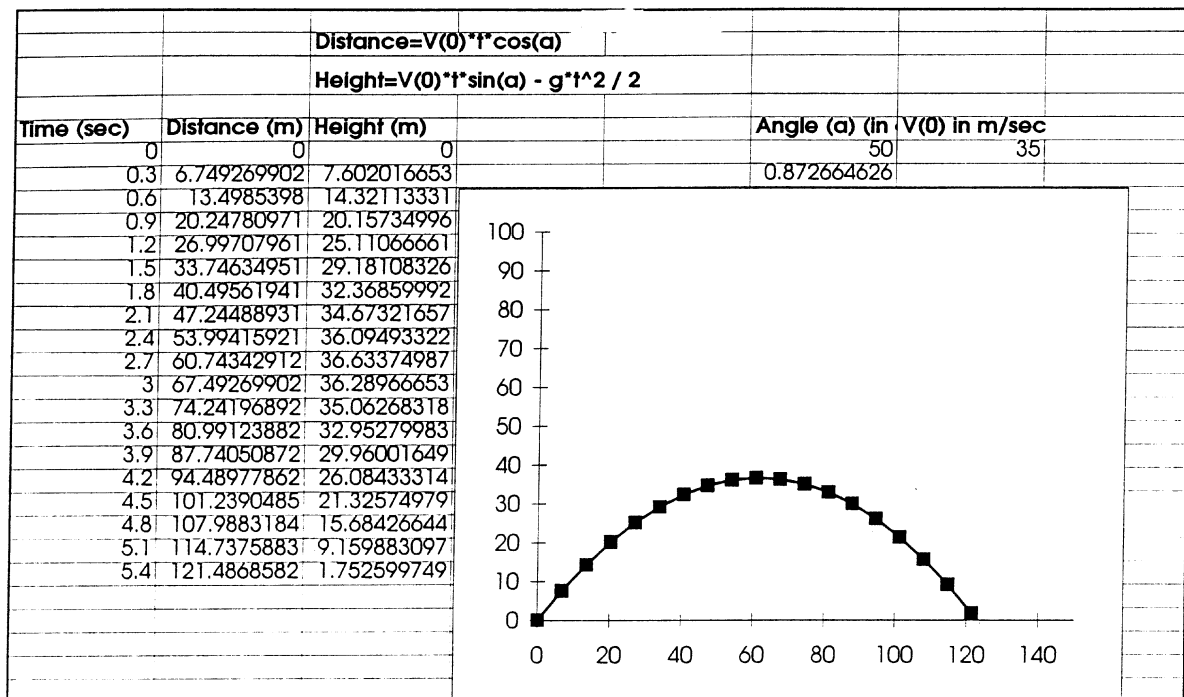


Fig. 5. Use of spreadsheet to solve projectile problem.

sheet as seen in a book. The equations and graphs are 'live' and a change in data redraws the graph. Also the symbolic capability helps them to solve a variety of analytical equations. The material they prepare, can be directly printed and no further handwritten or typed reports are needed.

The *Mathcad* software also tracks standard units during calculation and converts the units of calculated quantities automatically. Also interactive built-in tools to calculate mechanics quantities like moment of inertia etc. are available. All these desirable features help the student in focusing on the problem without making mistakes in calculation and unit conversion, Also some use of spreadsheets like Microsoft *Excel* [11] was encouraged throughout the course. Figure 5 shows the usage of spreadsheets to solve projective problem. Since spreadsheets are getting very powerful and their use in the industry is continuously increasing, we find it useful for the students to get proficient in this software tool.

CONCLUSION

The use of modern software tools to teach dynamics in engineering technology program has

been well received by the students. The engineering technology curriculum places equal if not more emphasis on the application of theory rather than the theory itself. The instructors try to use examples from the industry and try to use tools that are currently in use in the industry. In order to support this cause and to make best use of the current engineering textbooks available, the authors supplemented the theory with multimedia and other software tools. The use of multimedia was very rewarding as the students could visualize problems that are sometimes difficult to be explained in text books. Popular simulation tools from different vendors were used to analyze the problems and perform mathematical manipulations. This was necessary since the aim of the class was to understand each problem and identify the right mathematical expression for it and less time in solving various forms of the same mathematical expression. Lecture time was judiciously used to accommodate the text coverage, multimedia/simulation presentation, problem solving and discussion. In assigning homework problems, it was our intention to see to it that the students start thinking like engineers. So, problems highlighting design and safety issues were given preferential treatment during the problem selection process.

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