2006-298: THE USE OF COMPUTER SOFTWARE TO ENHANCE THE ANALYSIS WITHIN A MECHANISMS COURSE IN MECHANICAL ENGINEERING TECHNOLOGY

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The Use of Computer Software to Enhance the Analyses within a Mechanisms Course in Mechanical Engineering Technology

Abstract

A primary objective of a mechanisms course within any mechanical engineering technology curriculum is to be practical and applied and less theoretical. Examples are presented that suggest how various computer programs may be integrated into the syllabus of a mechanisms course to facilitate the successful accomplishment of this objective. These examples illustrate how several readily available computer programs along with traditional hand computational methods may be used to enhance and enliven the subject of mechanisms analysis.

Traditional computational methods augmented with computer programs familiar to all engineering technology students, are used to compute kinematics and kinetics quantities. Strong emphasis is placed on the verification and accuracy checking potential of this computer integrated approach.

Introduction

A typical course in mechanisms analysis frequently requires the use of traditional computational procedures that may place unnecessary limits on assigned projects. This paper suggests one possible alternative to the "snap-shot" approach to the analyses of mechanism configurations. Typically, students are more energized and motivated to learn and retain concepts when courses contain computer laboratory experiences. A new course in mechanisms analysis was designed by the author and included within the curriculum of a newly created baccalaureate program in mechanical engineering technology at Miami University. The program was officially approved in the spring of 2003 and course offerings were begun in the fall of the same year. Hence the data confirming and/or refuting the above premise is limited.

While many mechanisms courses currently being taught within the curriculums of mechanical engineering technology programs make use of computer enhanced project assignments, the author believes that this paper presents a more formalized outline to accomplish the objective of a more interesting and practical course. The course content was purposely designed to strongly emphasize the integration of several readily available computer programs with traditional hand computational methods. The course syllabus requires students, working in teams of two, to complete a course portfolio consisting of assigned mechanisms analysis projects that must clearly illustrate the use of traditional algebraic and trigonometric as well as computer based computational methods.

Pedagogical Structure

Mechanisms for Machine Design, ENT 314, is a three credit hour, required course, within the curriculum of the Mechanical Engineering Technology program at Miami University. The course is divided into the two traditional major topics, kinematics and kinetics. Time distribution for the two topics is approximately 70% kinematics and 30% kinetics with the kinetics portion occurring during the latter part of a sixteen week semester. A generic list of the computer software programs currently utilized within the course include: word processing, spread-sheet, two dimensional CAD, and two dimensional rigid body animation simulation. The computer laboratory component of the course is scheduled in an engineering technology department computer laboratory within which all necessary software is made available to the students. Time allocation for the three credit hour course is divided into two contact hours of lecture and two contact hours of computer laboratory per week.

The course syllabus stresses the use of a combined computational approach to mechanisms analysis. When practical, assigned projects in the course must demonstrate either parallel or combined solutions using traditional hand computations and the use of computer software. Additionally, a substantial number of projects are assigned that require the representation of mechanisms analysis for multiple configurations. Practically, many of these projects may only be completed using computer software analysis. Parallel computational solutions (traditional and computer based) are assigned that permit students and instructor to verify analysis outcomes and perform accuracy checks. Project assignments that require the analysis results to be presented for multiple mechanism configurations clearly demonstrate how substantial analysis improvements may be achieved using computerized computations.

As a means of encouraging teamwork, students are divided into teams of two and all project work within the course is presented to the instructor at the end of the semester in three ring binder portfolios. All tests are given in class and required to be completed within a preset time period. The required text book was specifically chosen based on the fact that its author constructed all chapters to emphasize both the use of manual computational methods and computer software to solve two dimensional mechanisms analysis problems.

The mechanisms course is a prerequisite of the senior design capstone course. The elements of the design course process include but are not limited to: establishment of objectives, synthesis of ideas, and mechanical analysis of the selected components of the project. Real-world constraints such as economical and societal factors, marketability, ergonomics, safety, aesthetics, and ethics are also an integral part of this capstone course. A major requirement of all senior design projects is that each final report and oral presentation clearly demonstrates practical applications of concepts and methods learned in other engineering technology courses. The course project reports and final oral presentations are required to contain examples of graphical and computational methods and procedures learned in areas such as: computer aided drafting and design, machine design, mechanisms analysis, finite element modeling and analysis, and mechanical vibrations. Thus the example course used within this paper, Mechanisms for Machine Design, is clearly an important part of this requirement within the senior capstone course and to the program in general.

Method of Presentation

All course lectures are supplemented by the use of electronic slide presentations. Each slide presentation is made available to students through the department file server. When applicable, computer software examples are embedded within these slide presentations that help illustrate how computer generated data may be used within subsequent project assignments. Figures 1, 2, and 3 are examples of how these presentations are used to reinforce the concepts of integrated traditional and computerized mechanism analyses. Figure 1 illustrates the use of two dimensional CAD and rigid body animation software to enhance the concepts of kinematics diagrams and plane mechanism mobility. The kinematics diagram is shown animated within the electronic slide presentation. Figure 2 illustrates the use of parallel computation utilizing a two dimensional CAD software program and hand computation to construct a vector polygon. Figure 3 illustrates the use of a computer spread-sheet to plot data generated within the spread-sheet software of the profile of a two dimensional plate cam.

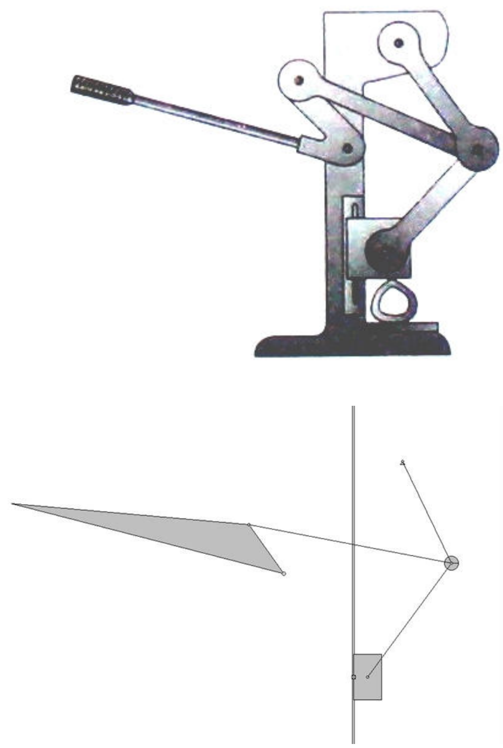

Figure 1

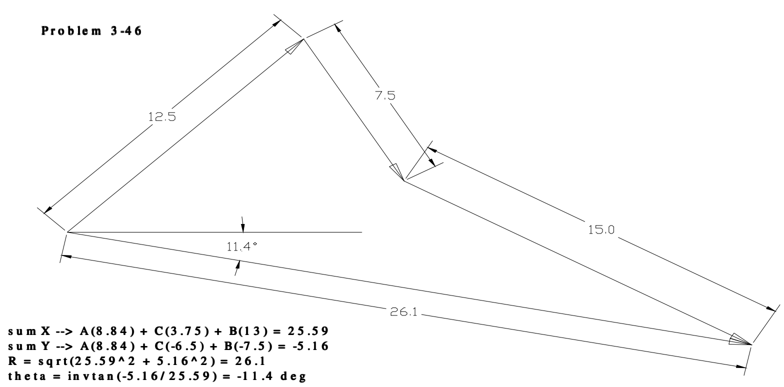

Figure 2

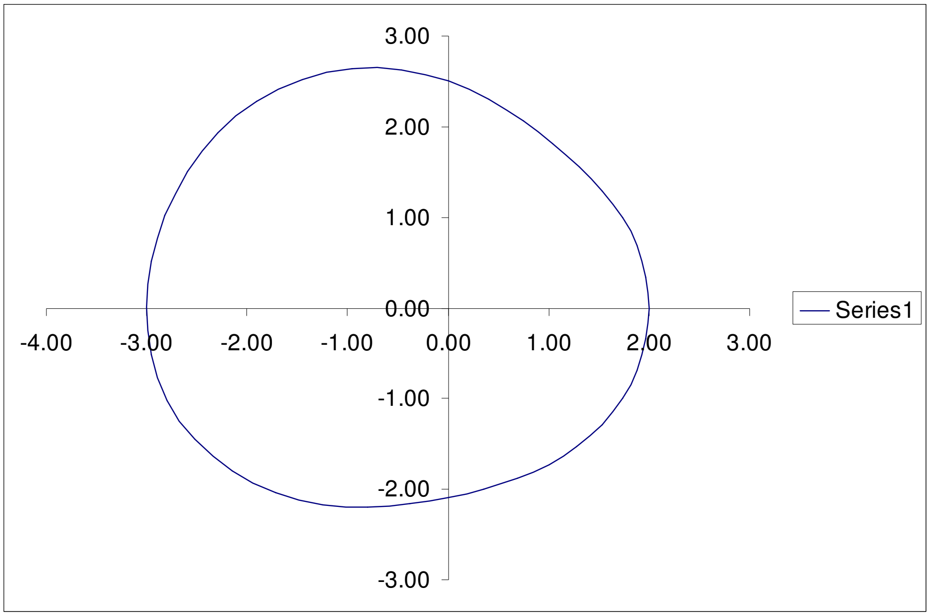

Figure 3

Student Portfolios

The primary intent of student portfolio projects is to teach how straightforward computational methods that are directly compatible with easy to implement computer software programs may be applied to mechanisms analysis. This section presents and briefly discusses selected examples of course project assignments taken directly from student portfolios.

Figure 4 is an example of combined computational approach using a CAD sketch of a kinematics diagram that contains six links and seven primary joints. Gruebler's mobility formula is used to hand compute the degree(s) of freedom for the mechanism.

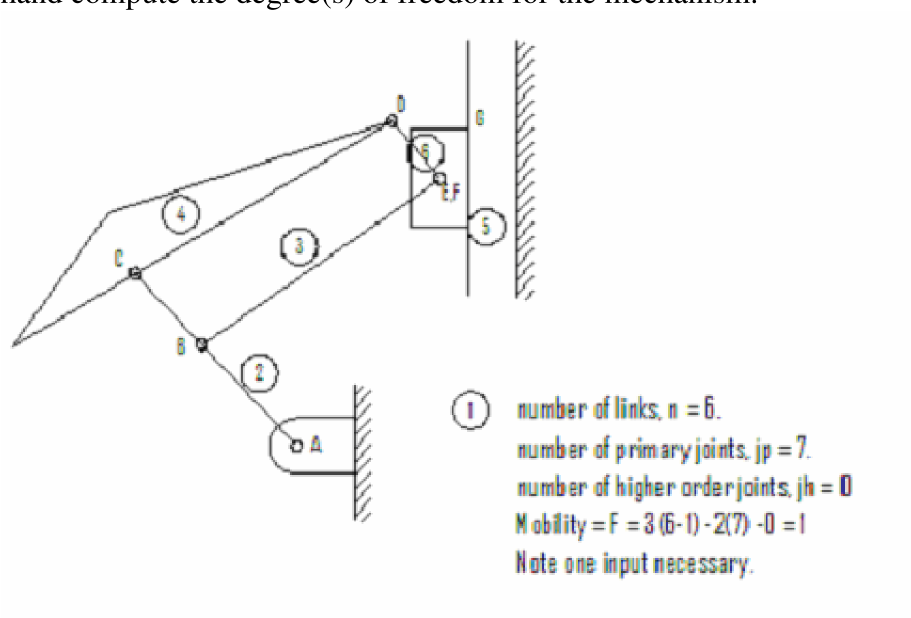

Figure 4

Figure 5 represents a graphical method using CAD software to synthesize a four-bar mechanism that satisfies three point position constraints for the ends of the coupler. Though not shown students were required to make parallel constructions using manual lay-out.

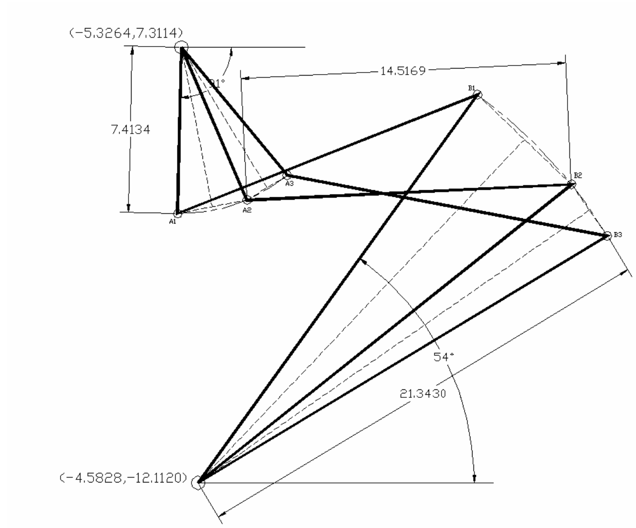

Figure 5

Figures 6 and 7 represent the partial results of a portfolio assignment that required a parallel solution of an in-line slider crank mechanism using computer animation software to help verify the hand computed solution for a single configuration of the mechanism. Only the hand-sketched acceleration vector polygon is shown for brevity. The force/moment free body diagrams have also been omitted. It was required that the input motor torque be determined for the snap-shot configuration of the mechanism shown in figure 7. Verification was achieved much to the student's satisfaction.

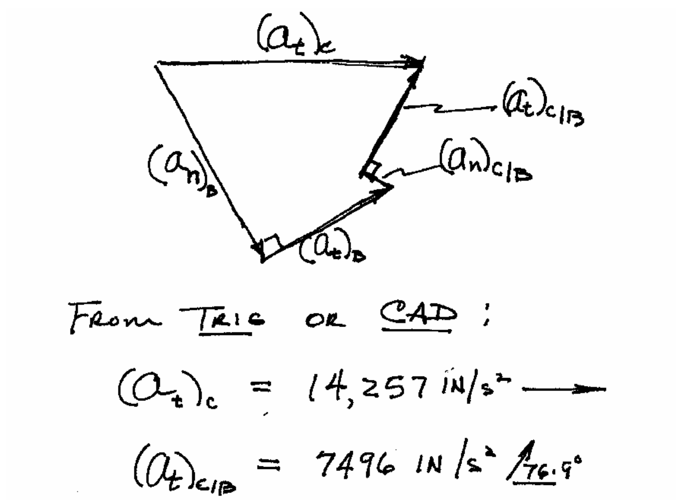

Figure 6

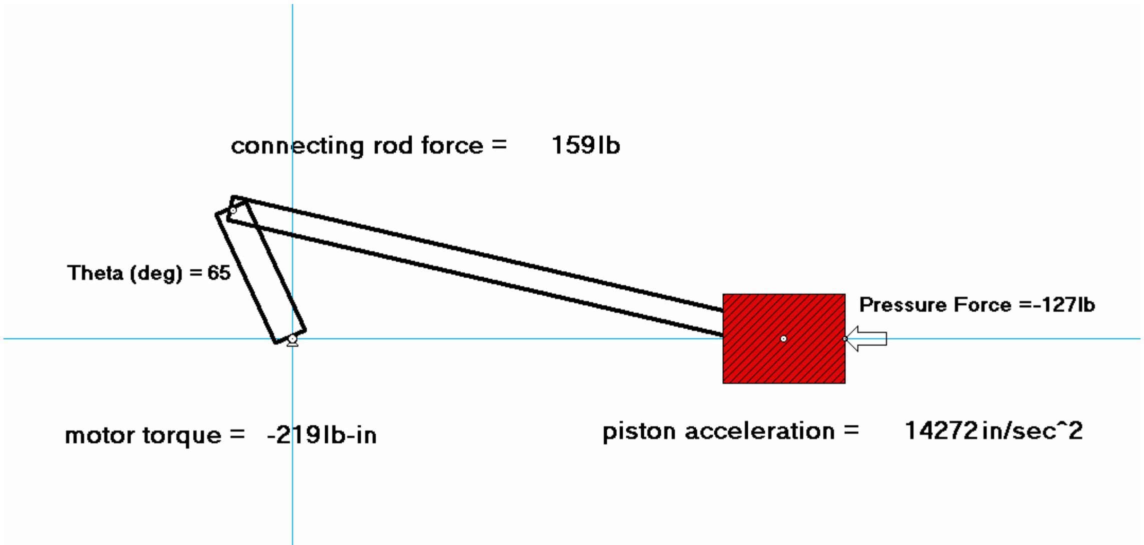

Figure 7

Conclusions

The preceding portfolio examples represent only a small sampling of the total scope and number of course portfolio assignments, but do, however, serve to illustrate how an integrated approach to teaching a mechanisms course may easily be included within the course curriculum. The preceding figures and their related discussions help outline a more formalized approach for the inclusion of simple to use computer software in a mechanisms course.

Limited course evaluation data is available. A review of student course evaluations for the spring of 2004 and 2005 shows, for the question: whether the students considered the course laboratory and homework activities to be effective learning tools yielded scores of 3.80 and 3.60 respectively out of 4.00. Anecdotally, the author has taught this course several times before (many years ago) without the use of computerized computational tools and is honestly able to comment positively on the relative improvements achieved. Students enrolled in the computer integrated course were much more empowered to learn basic concepts while exploring knowledge-broadening "what-if" scenarios than those enrolled in the non-computer integrated course. Student visualization of mechanism configurations, applications, and cyclical operations were practically non existent in the courses without computer integration. Using the computer integrated approach, course instructional sessions were significantly enhanced by increased student interest and attention. Based on the above observations, the author believes that improvements in student learning and instructor effectiveness may be achieved when the course curriculum includes an integrated approach to computational activities. Much more data is required in order to reach any statistically accurate conclusions.

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