

**Revamping EDICS: the Engineering-Design
Instructional Computer System**

by

Melody T. Yung

B.S. Mechanical Engineering
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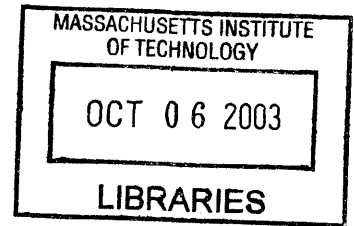
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Author: _____

Department of Mechanical Engineering
August 1, 2003

Certified by: _____

David Gordon Wilson
Professor of Mechanical Engineering, Emeritus
Thesis Supervisor

Accepted by: _____

Ain A. Sonin
Chairman, Department Committee on Graduate Students

BARKER

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ABSTRACT

As the internet continues to grow, technological advances have made it possible to develop new methods of teaching that were never before possible. With the accelerated evolution of hardware and software, there has been a marked increase in the use of computer-based teaching worldwide. During the past few years, engineering faculty have been creating new ways to help their students gain a better understanding of concepts being taught in class. For example, instructional CD-ROMs and online tutorials have been developed to teach students about mechanics, thermodynamics, manufacturing, and other areas of engineering.

In spite of this recent trend, there has been little development of multimedia-enhanced educational tools geared toward teaching the fundamentals of engineering design, e.g. bearings, shaft-to-rotor connections, fasteners, etc. An interactive program called EDICS (Engineering-Design Instructional Computer System) could be used to address this issue.

In this thesis, we give an outline of how the existing chapters of EDICS were reconfigured in the form of web-based modules. Topics covered include: bearings, how to connect and cap cylinders, how to connect shafts to rotors, and engineering drawing. In addition, the design and implementation of a new module on fastening and joining methods is discussed in detail.

Thesis Supervisor: David Gordon Wilson
Title: Professor of Mechanical Engineering, Emeritus

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Chapter 1

Introduction

1.1 BACKGROUND

During the past two decades, mechanical-engineering professors noticed that, among college undergraduates, the proportion of incoming students with prior experience in mechanical design was steadily decreasing. Some students had grown up taking things apart, while others had never before been inside a machine shop. Also, many students were unfamiliar with common design terminology, such as bearing or gasket. Due to an increasingly diverse student body, it was hard to ensure that all students started out with the same background knowledge and experience.

The dilemma of teaching students the basics of mechanical design could be solved using a greatly expanded version of EDICS, the Engineering-Design Instructional Computer System. It was developed to help “motivated but relatively inexperienced mechanical-engineering students to catch up with their better-prepared classmates” [Wilson & Blanco 91]. In its present state, it allows students to fill in potential gaps in their design background, or to simply review design topics with which they are already familiar. EDICS utilizes full-color images, animations, and digital video to illustrate basic design concepts. Unlike a reference book, the software provides an interactive medium that provides students with a more hands-on experience.

The intended audience for EDICS is people ages 15 and older. By that age, most people will have been exposed to toys and other common forms of hardware relevant to the study of mechanical-engineering design. For instance, they will have used or perhaps taken apart a bicycle. While EDICS is suitable for students at the high-school or college level, it is also useful for adults who want a refresher course in the basics of engineering design and machine elements. More advanced features can be accessed by those who already have a good background or several years of design experience.

1.2 HISTORY OF EDICS

EDICS has evolved steadily over the past two decades. Its development began in 1984 with the help of seed funding from MIT's Project Athena, which was sponsored by DEC and IBM. Professor David Gordon Wilson was the principal investigator, while Seichi Tsutsumi, an officer in MIT's Industrial Liaison Program with a strong and increasing interest in video production, was the co-principal investigator. Shortly afterward, Professor Ernesto Blanco joined the EDICS project as a co-principal investigator, and Professor Woodie Flowers became a consultant for a short period. Initial work was done using a DEC IVIS (Interactive Video Instructional System). The setup was a bit cumbersome and impractical, but the IVIS was the only choice available.

The project stalled for a short time, but in 1988, EDICS development began anew after Wilson successfully sought funding from the National Science Foundation. A graduate student, Douglas Marsden, was hired to work on EDICS as a research assistant. About ten undergraduates were hired via UROP (Undergraduate Research Opportunities Program) funds. Blanco remained on the project as a co-PI. Marsden, with the help of enthusiastic UROP students and a few freelance workers, completed the first version of

EDICS using Apple Macintosh's HyperCard 1.0 system [Marsden 90]. Chapters were created on bearings, on how to connect and cap cylinders, and on choosing shaft-to-rotor connections. Pedagogical strategy was developed by MIT faculty members (Wilson and Blanco), as well as most of the textual and illustrative content. Decisions on video and sound recording were made by Tsutsumi. To use this version of EDICS, a Macintosh computer running HyperCard was required, along with thirteen floppy disks. Also, a TV monitor and a laser-disk player were used to display video clips [Wilson & Blanco 91].

In 1990, David Crismond became the new graduate research assistant. He was in charge of converting EDICS from HyperCard 1.0 to 2.0 format. The hardware requirements for running the program remained the same. Crismond also performed a comprehensive evaluation of EDICS using student subjects from MIT's introductory design course 2.70, as well as other undergraduates [Crismond 92]. In his study, he compared the effectiveness of learning design via EDICS versus text learning alone. Crismond found that students who used the interactive version of EDICS scored much higher in the areas of analogical reasoning and estimation.

After Crismond graduated in 1992, Sepehr Kiani became the research assistant on the EDICS project. Using the Macintosh system, a new chapter of EDICS was created on the topic of engineering drawing. Due to a shift in funding and also changes in the market, there was a push to create a PC-compatible version of EDICS. As a result, Kiani took a new approach and developed a case study of the design of a human-powered hydrofoil [Kiani 94]. This new chapter was developed using Visual Basic under the Microsoft Windows operating system. Kiani performed an evaluation of this design-process chapter by testing ten students from the mechanical-engineering department.

Although not all of the intended subject matter was conveyed to the students, they did enjoy the multimedia approach that EDICS offered.

In 1996, EDICS was released on a Macintosh CD-ROM by Center Vision, a company founded by Tsutsumi after he left MIT. It included the original four chapters on bearings, cylinders, shafts-rotors, and engineering drawing. In this version, new navigational controls and other features were added via scripts written in SuperCard, an authoring tool very similar to HyperCard. In October of that year, EDICS was awarded first prize in the higher-education category from the Massachusetts Interactive Media Council, which cited it as “a model for educational titles, using humor and clear presentation to educate.” Copies of EDICS were given to over ten universities and a few high schools for evaluation. Although feedback was somewhat low in quantity, it was universally positive.

1.3 CURRENT TRENDS

There has been a huge jump in the number of multimedia applications developed to aid students in the classroom. Due to rapid advances in technology, college faculty around the world have begun to incorporate computer-based teaching methods into their lectures. Both stand-alone CD-ROM's and web-based learning modules have played a role in this educational revolution. The prices of once-expensive hardware and software have continually decreased as well, making things more affordable for everyone.

Numerous studies conducted during the past few years have shown the value and usefulness of computer-based teaching. According to a report released by the ERIC (Educational Resources Information Center) Clearinghouse on Adult, Career, and Vocational Education, “reduced training costs, worldwide accessibility, and improved

technological capabilities have made web-based training a viable alternative to classroom instruction” [Brown 00]. At MIT, Professor David Wallace showed that college students who watched web-based lectures could learn the class material just as well as those who attended traditional classroom lectures. The study was conducted with the help of students enrolled in a graduate-level course on product design [Wallace & Mutooni 97]. At the University of Alabama-Huntsville, Sonali Pathak showed that including computer animations in an interactive tutorial increased student retention of concepts taught in a course on human anatomy [Pathak 99]. Similar results were found at Minnesota State University. Professor Muhammad Khaliq showed that using interactive teaching tools in an electrical engineering course had a “positive impact on student learning” [Khaliq 01]. At the University of Cincinnati, several engineering faculty also confirmed that introducing new instructional technologies led to better student performance [Rutz 03].

Computer-based teaching techniques have also benefited students at the high-school level. In 2001, Thomas Gray showed that the use of full-color images and animations deepened student understanding of the concepts of torque, angular velocity, power, and gear ratios [Gray 01]. All of the students who participated in that study were members of high-school robotics teams.

Encouraged by these findings, engineering faculty around the world have been making use of innovative teaching methods. Some of the recent developments are summarized below.

1.3.1 Related work at MIT

The use of computer-based teaching methods at MIT has increased dramatically during the past few years. This can be partly attributed to the MIT-Microsoft iCampus

initiative. Announced in October 1999, this five-year alliance was formed to encourage the use of information technology to enhance learning opportunities. Microsoft Research provided funding for the development of new educational tools in a variety of courses from multiple departments. The following are some of the iCampus-sponsored projects from MIT's school of engineering.

The concept of "active-learning environments" was introduced in an undergraduate course on structural mechanics (course number 1.050) in the civil-engineering department [Shepherdson 01]. As part of the experiment, web-based learning modules were developed to supplement the lectures. As a whole, students responded favorably to the new, interactive mode of learning. Illustrated tutorials and simulations were also developed for a graduate-level course on fluid mechanics [Mei 02].

The iCampus alliance also funded projects in the mechanical-engineering department. For example, the introductory course on solid mechanics (course number 2.001) was completely revamped from its traditional lecture format [Sandhu 02]. The usual blackboard-based instruction was replaced by a new teaching paradigm. Web-based learning modules were developed for specific topics. In addition, each enrolled student was given a laptop to run the modules during lecture periods or at other times of their convenience, outside of the classroom. Interactive modules were also created for the department's principal courses on thermodynamics and fluid mechanics [Ozer 03].

1.3.2 Related work at other universities

There are numerous examples of the use of computer-based teaching by engineering faculty worldwide. At Humboldt State University, a set of tutorials and example problems were developed and compiled at a website named ThermoNet. Full-

color images, web animations, and videos were used to illustrate the laws of thermodynamics to mechanical-engineering undergraduates [Baker 01]. Similar instructional techniques have been used at the United States Air Force Academy in an introductory thermodynamics course [Byerley 01]. In both cases, the initiatives were meant to deepen the students' conceptual understanding of lecture material.

Web-based games and an instructional CD-ROM were used to teach students at the University of Texas-Pan American about engineering graphics [Crown 01]. Dimensioning and tolerancing were among the topics covered. In general, students improved their visualization skills and rarely needed help outside of the classroom.

Innovative techniques have also been used to teach manufacturing topics. At Utah State University, a series of multimedia-enhanced learning modules were developed for a manufacturing-processes lab course [Hailey & Hailey 00]. At the National University of Singapore, a web-based tutorial was developed to help engineering students learn about automated machine tools away from the traditional manufacturing environment [Ong & Mannan 02].

Educational tools have been developed for mechanics of materials too. The software package SEVE (Structural Engineering Visual Encyclopedia) was recently developed at the University of New Hampshire [Henry 99]. In addition to the explanatory text, SEVE uses sketches, photos, and graphic animations to illustrate terminology and concepts; examples are drawn from real-world applications. To date, SEVE has been used in six classes at UNH. Another comprehensive program geared toward undergraduates is MDSolids (Mechanics of Deformable Solids). Developed at Murray State University, the program is aimed at students who want to develop their

problem-solving skills [Philpot 00]. Similar tutorials have also been introduced in courses at the University of Missouri-Rolla [Philpot 02]. In fact, computer-based teaching aids seem to have been developed more frequently for courses on mechanics than for any other area of engineering. A possible reason for this trend is that proficiency in mechanics is required of students in nearly all engineering majors. This is also true for those studying physics and architecture.

1.3.3 Observations

Despite the adoption of new teaching techniques in numerous engineering courses, the use of multimedia-enhanced teaching has been relatively untapped in the area of engineering design. A comprehensive web-based tutorial on the basic elements of mechanical design has not been found. Also, few design courses emphasize practical knowledge of machine elements. Instead, many take a system-level view of the design process.

1.4 SUMMARY OF THESIS

The remaining chapters describe the work done for this thesis. Chapter two discusses the software and hardware that were chosen and used for the project. The third chapter outlines the process of converting EDICS from a Macintosh-based CD-ROM to a set of web-based modules. Chapter four describes the development of a new module of EDICS on the topic of fastening and joining methods. Finally, in the fifth chapter, conclusions are made, and recommendations are given for future work that should be done for EDICS. This thesis uses a considerable amount of technical jargon, with respect to computer hardware and software. For reference, a glossary is included in Appendix C.

Chapter 2

Technical Specifications

The newest version of EDICS which was available prior to this thesis was a Macintosh CD-ROM. Because it was platform-specific, those without access to a Mac could not use it. In the form of web-based modules, EDICS could be accessible to people using other operating systems, as well as Mac users. Careful considerations were made in determining the best course of action to meet this goal. The software and hardware used are documented below.

2.1 SOFTWARE USED

2.1.1 Authoring environment

Macromedia Director was used to develop the revamped version of EDICS. It is an advanced authoring tool used to create multimedia-rich presentations. It enables both linear and non-linear storytelling. Director was chosen mainly for its ease of use. Many built-in functions reduced the amount of programming that was necessary. It was simple to use for non-programmers, yet powerful in its ability to support a wide variety of audio and visual media. This development software was especially convenient to use because of its what-you-see-is-what-you-get approach.

In recent years, Macromedia products have emerged as popular tools for developing interactive teaching modules. For example, at the University of Arizona-

Tucson, an undergraduate course in mechanics was developed using Director, Flash, and Authorware [Budhu 02]. At the University of Massachusetts-Amherst, Macromedia tools were used to create teaching aids for a course on engineering economics. In particular, the instructor noted that the course materials created with Macromedia products were easily accessible to all users who visited the website [Terpenny 02]. Director was also the software of choice in the development of online tutorials for a lab class on fabrication of integrated circuits [Khaliq 01]. The same was true for the creation of web modules on structural mechanics [Shepherdson 01].

Usually, Director files are not made available online. Instead, they are converted to Shockwave format, a process that compresses them to about 20% of their original size. These compact files are then embedded into HTML code, to enable viewing on the internet. Shockwave is a file format that can be viewed using either Netscape or Internet Explorer. At most, a Shockwave “plug-in” may need to be downloaded and installed for the web browser. Also, Shockwave is fully supported on both Windows and Macintosh machines. This cross-platform compatibility was particularly appealing since it would allow users of either browser, running either type of operating system, to use EDICS.

Java was considered as an alternative authoring environment, but it was not used for several reasons. For example, Java applets could also be embedded in webpages like Shockwave files, but incorporating the text and graphics from each page of EDICS would have been a cumbersome task. Also, using Java would have required significantly greater programming skill, compared to using Director. For our purposes, the Lingo programming language inherent to Director was more than sufficient for writing short scripts and creating new functions that were not already built-in.

Using a combination of Javascript and HTML to create a web-based version of EDICS was also considered. However, this alternative was deemed rather cumbersome due to the difficulties of controlling digital video via this method.

The original programs that were used to create EDICS, HyperCard and SuperCard, were not viable options either. Because both authoring tools worked only on Macintosh computers, any application developed with either program would face the same limitation. Also, a direct conversion of EDICS to a web-based format was impossible. There was no software that could simply “translate” the contents of the CD: the work had to be done manually.

2.1.2 Video and audio files

Adobe Premiere was chosen to edit movies of QuickTime (MOV) format that were used on the CD-ROM. It was also used to create black-and-white animations in EDICS. Among its many features, Premiere can splice together multiple video files. It can add to movies a variety of visual effects or transitions, such as dissolving the screen or fading to black. In addition, this video-editing program supports a wide variety of media formats.

Other programs were also used in the video-editing process. For example, TMPGEnc was used to create MPEG-1 (MPG) versions of all the movies. Like Premiere, TMPGEnc can join several movie clips together, in addition to other editing features. The main difference is that the resulting video is always in MPG format. Unlike proprietary software, TMPGEnc is an example of freeware, a term that refers to software that is freely available for anyone to download from the web. There is no required fee or payment for use of this product. A snapshot of the TMPGEnc program window is shown

in Figure 2-1.

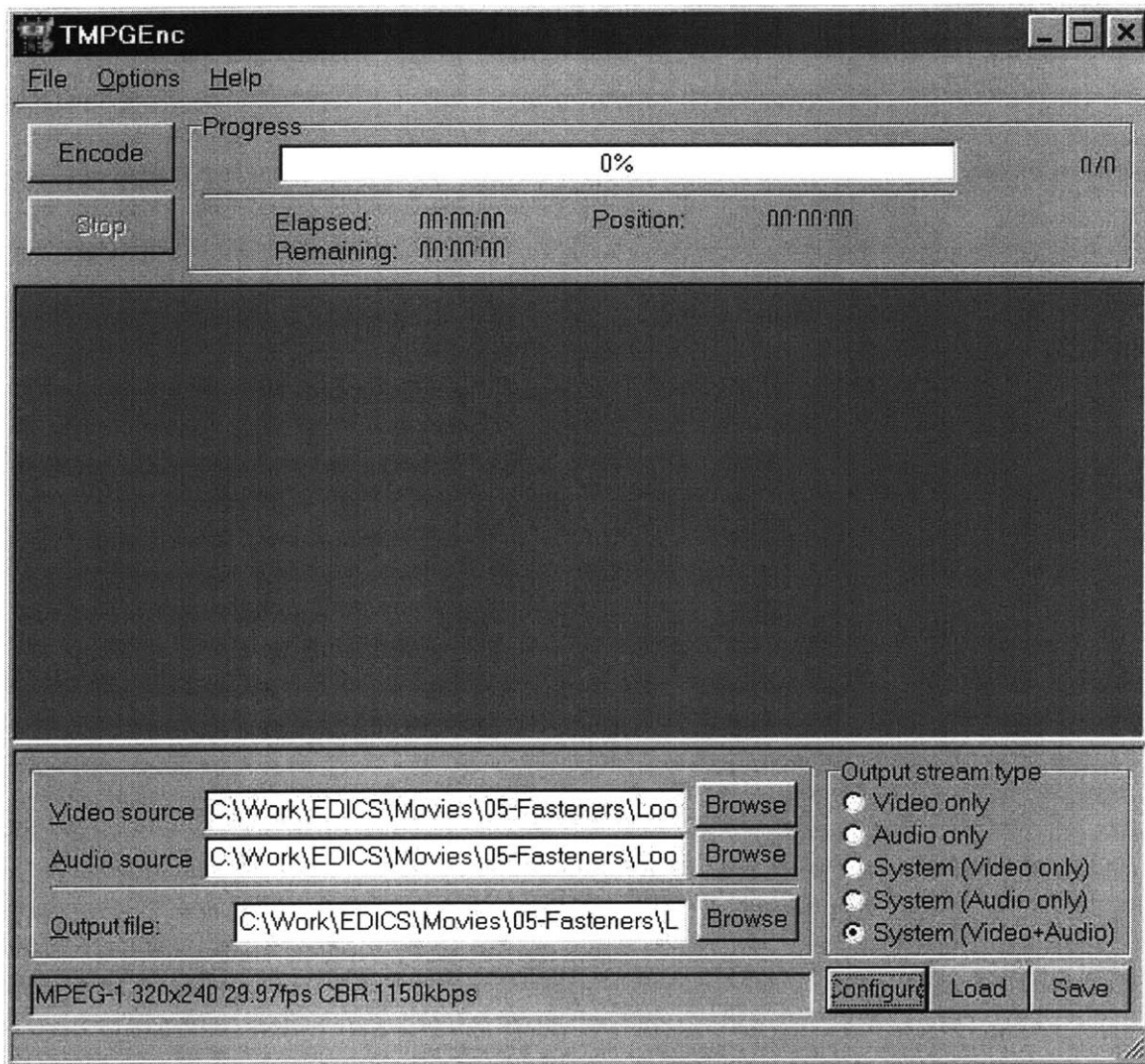


FIGURE 2-1: PROCESSING WINDOW OF THE TMPGENC PROGRAM.

Two alternatives were considered for creating MPG clips. The Ligos LSX-MPEG Encoder offered high-quality video output and a range of advanced features. However, its video input capability was limited to files of AVI format. In other words, it was unable to process files of any other type. The XingMPEG Encoder was also tested, but the quality of the video output was somewhat lower than desired. In particular, there was

noticeable pixellation. Based on these trials, both applications were dropped from consideration.

Real Producer Plus G2 was used to encode Real Media (RM) versions of each EDICS video. These copies were created with low-bandwidth users in mind. Real Text, another product from Real Networks, was considered for producing closed captions or subtitles for the video clips. However, due to time constraints, subtitles were not incorporated into this version of EDICS.

There were a few audio clips in EDICS, such as sound effects and jingles, that had to be processed. Virtual Dub, another example of freeware, was used to extract and edit them. Shown in Figure 2-2 is a snapshot of the window when the program is started.

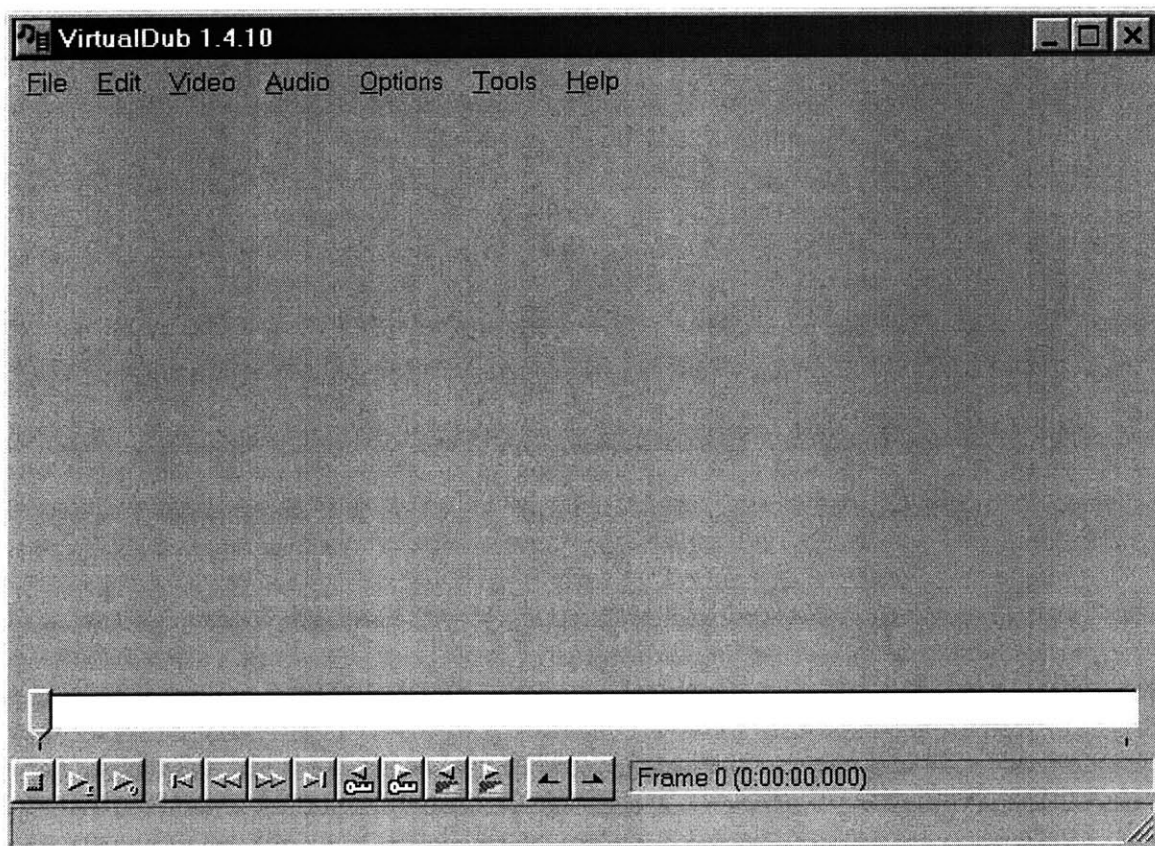


FIGURE 2-2: PROCESSING WINDOW OF THE VIRTUAL-DUB PROGRAM.

2.1.3 Graphics

Adobe Photoshop was chosen to create or edit all image files. It has a large array of tools and filters that can be used to alter images as needed. Photoshop also supports many image-file formats like BMP, JPG, GIF, PNG, and TIF.

2.1.4 Other software

Macromedia Flash was used to recreate two interactive quizzes from the EDICS CD-ROM. This software is very similar to Director, but it contains slightly fewer features. Whereas multimedia presentations created by Flash can be deployed only online, those created by Director can be released on the web or as stand-alone applications on CD or DVD. Also, Director supports a wider range of video and audio file formats.

Although SuperCard was not chosen as the authoring tool for this project, it was used on the Mac to access each chapter of EDICS. It was necessary in order to copy the text from each page.

2.2 HARDWARE USED

2.2.1 Windows PC

For most of the work, an Intel Pentium III 1189-MHz computer running Windows 98 SE was used. It had 256 MB of RAM and 85 GB of hard-disk space. Although there were higher-end computers available, with faster processors and greater memory storage, it seemed advisable to use a computer that was not quite “top-of-the-line” so that it would be easier to test EDICS performance for older machines. As of this writing, the fastest PC’s could operate at 3.2 GHz, equipped with 768 MB of RAM and a 250 GB hard-disk.

2.2.2 Apple Macintosh

A PowerMac 200-MHz computer running Macintosh OS 8.0.1 was also critical in the conversion process. The machine ran all operations sufficiently with 64 MB of RAM, although some of the programs would have run more smoothly if greater memory had been available.

2.2.3 Video capture card

The video capture card was a very important piece of hardware. An ATI Rage-128 card was used to capture video directly from laser disk or videotape to the hard-disk drive of the Windows PC. This ATI model was capable of capturing twenty-minute chunks of uncompressed video in the Windows-only AVI format, at a maximum rate of 30 fps (frames per second) and with a resolution of up to 640x480 pixels. It was also possible for the video card to “digitize” up to one hour of continuous video in MPG format, at the same frame rate and resolution as before. Other key components of the digitizing process included a Pioneer LD player (model no. CLD-S104) and a Panasonic SVHS VCR (model no. PV-S7670).

2.2.4 Computer monitor

A Magnavox 19-inch color monitor was used. It supported 32-bit color and a maximum screen resolution of 1600x1200 pixels. This monitor was used in conjunction with both the Windows and Macintosh computers. With the help of a heavy-duty data-switch, it was possible to switch back and forth between both screens. By sharing one monitor for both computers, the equipment required to complete the EDICS conversion was reduced.

2.3 PLAYBACK REQUIREMENTS - HARDWARE

For Macintosh users, a PowerMac 200-MHz computer running Mac OS 8.1 or higher is required. For PC users, an Intel Pentium II 266-MHz machine running Windows 98 or higher is needed. Any setup with an equivalent processor speed would also be fine, e.g. an AMD Athlon computer. In any case, 64 MB of RAM should be enough to run EDICS; however, 96 MB is recommended. A color monitor that supports 24-bit color and a full-screen resolution of 800x600 pixels should suffice. A sound card is also required to listen to the audio portion of the video clips.

2.4 PLAYBACK REQUIREMENTS – SOFTWARE

Macromedia's Shockwave Player, version 8.0 or higher, is required. It is available for free at this site: <http://www.macromedia.com/shockwave/download/>.

For Netscape users, version 4.6 or higher will work. For those who prefer Internet Explorer, version 4.0 or higher should be installed on the machine. Older versions of the two web browsers may also work, but they have not been tested. EDICS has not been tested on any versions of Opera or Mozilla either.

To view the video clips, Windows users should have QuickTime Player, version 5.0 or higher, installed. Macintosh users need to use version 3.0 or higher. This is available at the official Apple website: <http://www.apple.com/quicktime/download/>. For those running Linux, the video clips can be viewed using MPlayer, which is available at this website: <http://www.mplayerhq.hu/>.

2.5 OTHER TECHNICAL NOTES

MPEG-1 (MPG) was chosen for the final video format, instead of QuickTime

(MOV). One of the reasons was ease of editing. There was a variety of freeware tools available online that could be used to edit MPG videos, whereas editing MOV files was impossible without proprietary software. Also, both Windows Media Player and QuickTime Player could be used to watch MPG videos. On the other hand, only the latter could be used to play back MOV files. Flexibility in editing and playback was a big plus.

Chapter 3

EDICS Conversion

Converting EDICS to a series of web-based modules involved a multi-step process. All images, animations, text, and digital video files used on the Macintosh CD-ROM had to be processed before they were imported into Director. Details of the procedures are given in the following sections.

3.1 GRAPHICS

Adobe Photoshop was used on both the Macintosh and Windows PC to edit images from EDICS. Regardless of the file type, holding down the Command and] keys simultaneously on the Mac keyboard was necessary to enable copying-and-pasting of graphics from each page of EDICS. Most of them were already in PC-compatible formats, such as BMP, JPG, and GIF. However, some images were in the Macintosh-native PICT format. In those cases, they were converted to another file type. In general, color images were saved in BMP or JPG format, while all black-and-white ones were kept in GIF format.

3.2 ANIMATIONS

The animations used on the EDICS CD consisted of three different file formats. Some were animated-gif files. Others were designated as “Studio-1” or “MacroMind”

though, formats that were obsolete. The software required to open and view them were no longer in use either. In addition, Studio-1 was a Macintosh-only type of medium, so all such files had to be converted to another format. Since animated-gif files could be easily viewed in web browsers on both Windows and Mac platforms, it was chosen as the alternative format. To keep all the animations consistent, MacroMind files were recreated in the same way.

3.3 DIGITAL VIDEO

The videos used in the updated Bearings chapter were captured directly from the original EDICS laser disk (LD). Since this prototype LD did not include clips that were later recorded for the Cylinders and Shafts-Rotors chapters, those videos had to be converted directly from the EDICS CD. No additional video was ever recorded for the Drawing chapter, so that was not an issue.

3.3.1 Bearings chapter

All of the videos for the Bearings chapter were digitized at a resolution of 352x240 pixels and a frame rate of 29.97 fps (frames per second), based on an NTSC standard. The sampling frequency was set to 44.1 kHz, while the channel mode was set to 16-bit stereo. Each movie was saved in uncompressed AVI format and stored on the hard-disk drive of the Windows PC. Most clips ranged in size between 50 and 100 MB. Because these “raw” files were far too large for delivery over the web, they were subsequently encoded as MPG files using TMPGEnc. The video and audio bit rates used were 1150 and 128 kbps (kilobits per second), respectively. This compression process significantly reduced the size of each file, without any noticeable quality loss in either the

audio or video. In fact, the newly encoded movies were smaller than 20 MB, with many of them under 5 MB.

3.3.2 Cylinders and shafts-rotors chapters

All of the digital videos on the CD were specifically Macintosh-only files. As a result, they had to be converted to a PC-compatible format using Adobe Premiere. To do so, a relatively simple import-and-export operation was used. For all clips, the video resolution of 240x180 pixels and the frame rate of 15 fps (frames per second) were kept the same as they were on the CD. Audio settings were also left unchanged. By default, the Cinepak video codec was used. After the files were processed by Premiere, only a few of them exceeded 5 MB in size.

3.4 TEXT

To process the text in EDICS, each section had to be opened using SuperCard. The text from each page was copied via the CTRL-A command and pasted into a text editor on the PowerMac. Any misspelled words or grammatical errors were corrected at this point. Each text file was subsequently copied onto a 3.5-inch floppy disk and transferred to the Windows PC. From that point, text was incorporated directly from each file into Director.

3.5 DEVELOPMENT USING DIRECTOR

3.5.1 General decisions

A resolution of 640x480 pixels was chosen for the main program layout. Most websites have been designed for viewing with 800x600 screen resolution, so it seemed reasonable to make the new EDICS window slightly smaller than that.

To prevent user confusion, all navigational buttons were kept in the same on-screen locations for each chapter of EDICS. For example, the QUIT, HELP, and MAP buttons were kept in the lower left corner of every page. On the other hand, the BACK and FORW buttons were located side-by-side in the lower right corner. The headings for each chapter and section were placed in the upper left and right corners, respectively.

On the CD-ROM, the cursor remained constant throughout EDICS, regardless of what was being accessed at any time. In the web-based version, two different cursor icons were used. By default, the “arrow” icon would appear on-screen. Whenever the mouse passed over a button or another object that could be clicked, the “finger” icon would show up instead. This was done to help users identify what could be clicked on.

Originally, each video clip was accessible by clicking on a button labeled with both the word “Example” and a film icon. Then, the movie would begin playing immediately in the upper right corner of the EDICS window. Either clicking the mouse again or letting the clip run its course would cause the movie to stop playing and disappear. That was a nice design, but there was no way of forwarding or rewinding the clip. It was also impossible to adjust the audio level as the movie was playing. For the web-based version of EDICS, the same basic design was used, but a few changes were made. When each video was imported into Director, a control panel along the bottom of the movie window was included. This would allow users to advance forward or move backward through a movie clip. The audio level was also adjustable for each video; it could even be muted if desired.

As for the text, the font style used on the CD-ROM was native to the Macintosh, so a new one had to be chosen for the web modules. The Windows-based font which

most closely resembled the original EDICS text was Arial Narrow; therefore, that was used. The font sizes were also chosen to emulate the ones used on the CD. The title of each page was set to 22-point size, while the text in the main body was set to 18-point. The font size of button labels was usually 10-point.

3.5.2 Bearings chapter

This module contained the most content and was geared toward students who had never before been exposed to bearings. It was comprised of nine sections: Introduction; Bearing physics; Design specs; Bearing types; Good practice; Examples; Bearing selection; Dictionary; and Self-test. A sample page from the module is shown below.

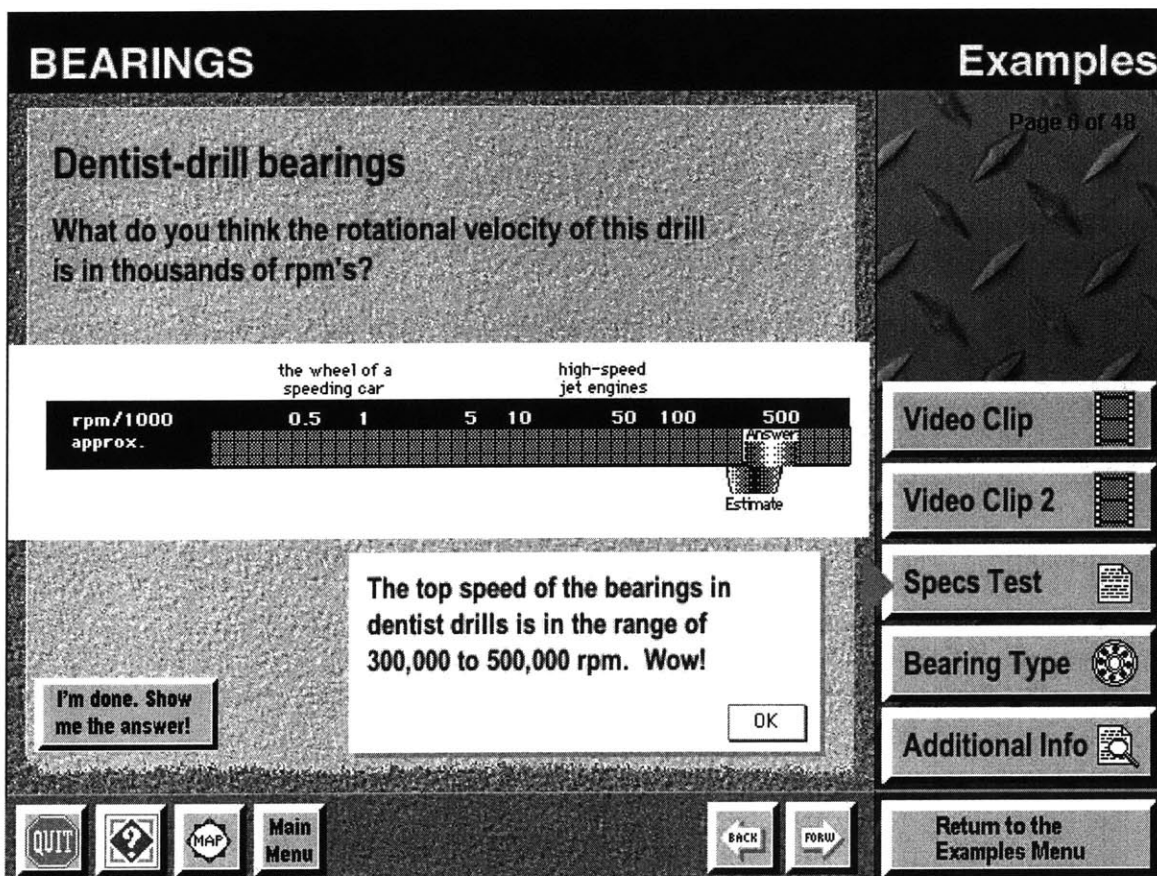


FIGURE 3-1: HANDS-ON EXERCISE FROM THE UPDATED BEARINGS MODULE.

There were 46 video clips in the Bearings unit. Movies were available in nearly every section, but most of them were featured in either Bearing types or Examples. Since all the clips used on the CD-ROM had a resolution of 240x180 pixels, the movies linked to Director were resized from 352x240 to the smaller resolution for consistency.

3.5.3 Cylinders chapter

In this module, proper ways of connecting and capping cylinders were discussed. Like the Bearings chapter, it was made up of nine sections: Introduction; Cylinder physics; Design specs; Connection types; Good practice; Examples; Selection system; Dictionary; and Self-test. The first page of the Self-test section is shown in Figure 3-2.

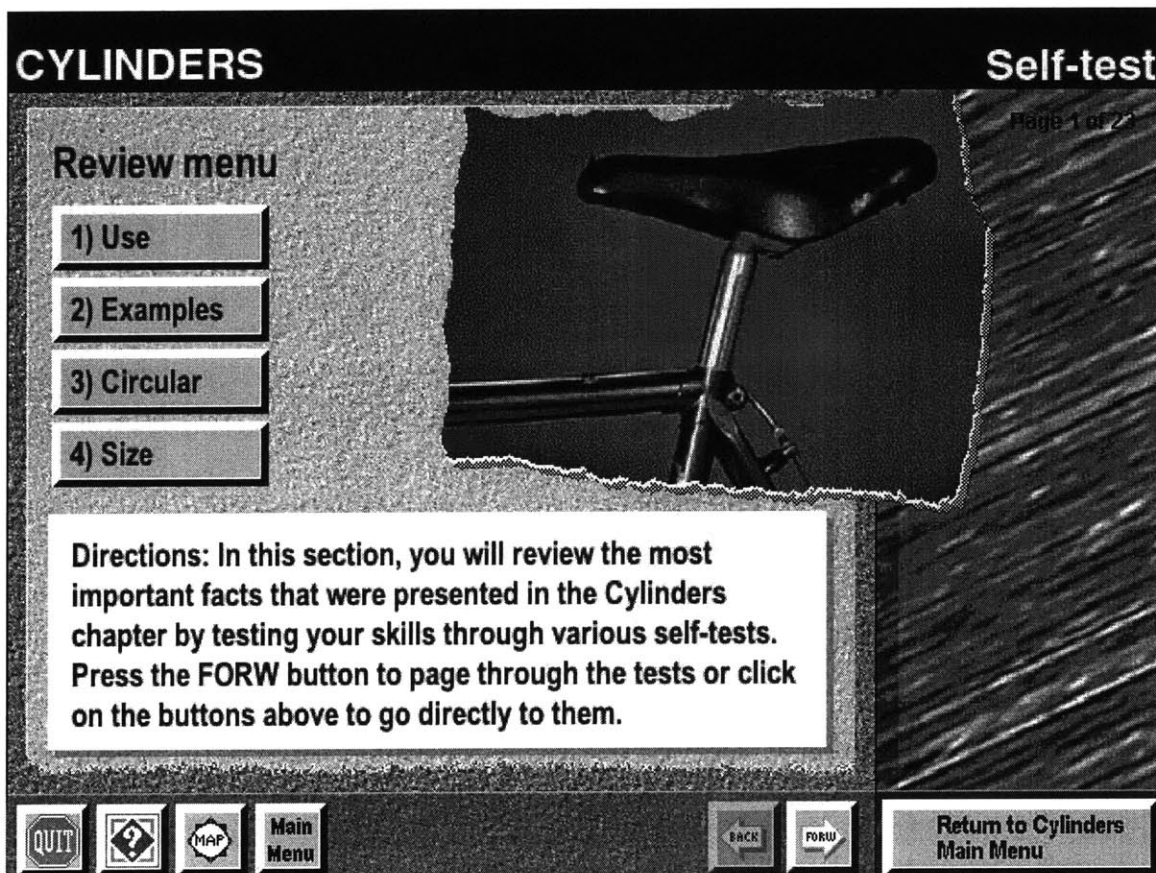


FIGURE 3-2: SELF-TEST FROM THE UPDATED CYLINDERS MODULE.

Movies were scattered throughout the Cylinders chapter, although most of them were linked to the Examples section. Overall, there were 23 video clips available.

3.5.4 Shafts-rotors chapter

This chapter showed how to design shaft-to-rotor connections in mechanical assemblies. It consisted of eight different sections: Introduction; Physics; Design specs; Connection types; Good practice; Examples; Dictionary; and Self-test. Shown in Figure 3-3 is a sample screen from Design specs.

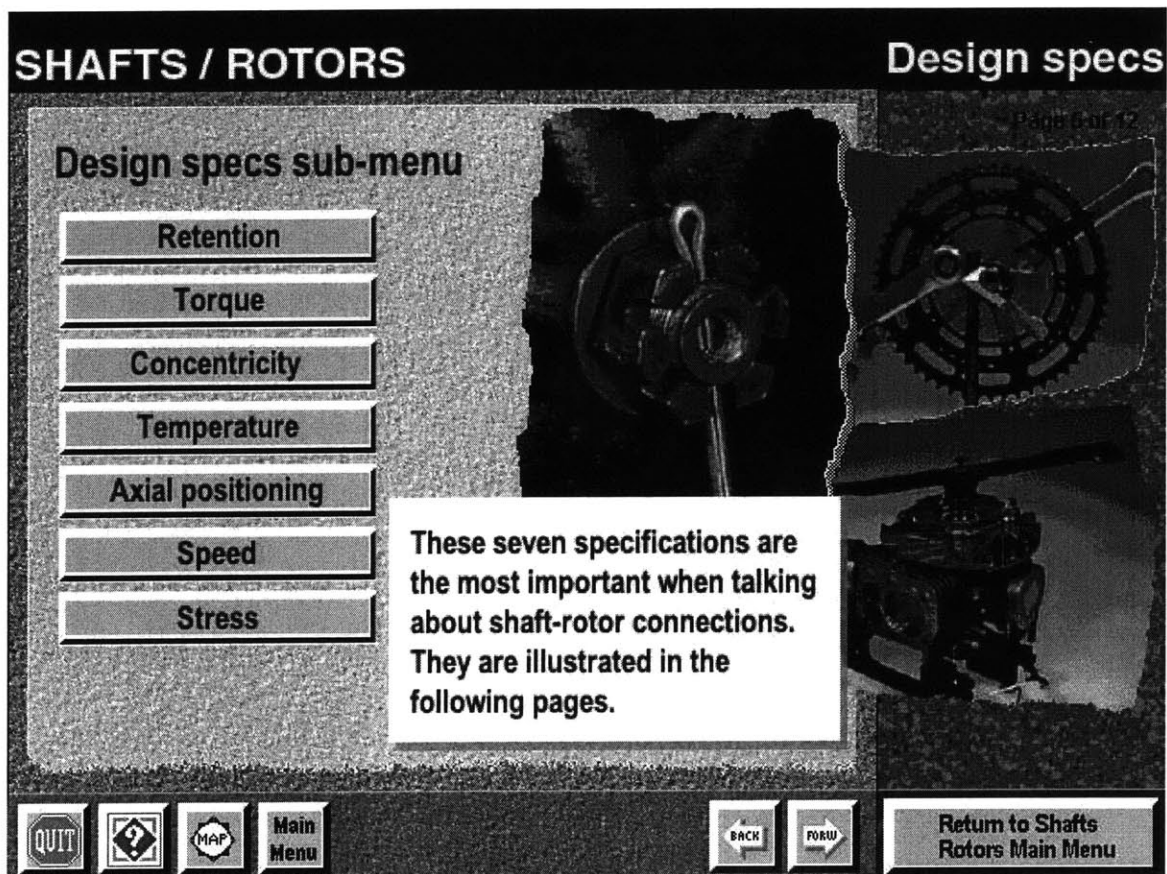


FIGURE 3-3: DESIGN SPECS FROM THE UPDATED SHAFTS-ROTORS MODULE.

In all, there were 31 video clips available in this chapter. Over half of them were linked to the Examples section, while the rest of them were distributed among the

remaining parts of the chapter.

3.5.5 Drawing chapter

This was the shortest of the four topics on the CD-ROM. Unlike the first three chapters, it contained only four sections: Introduction; Sections; Dimensions; and Tolerancing. Nonetheless, the material covered was vital to understanding the basics of engineering drawing. An interactive exercise from this chapter is shown below.

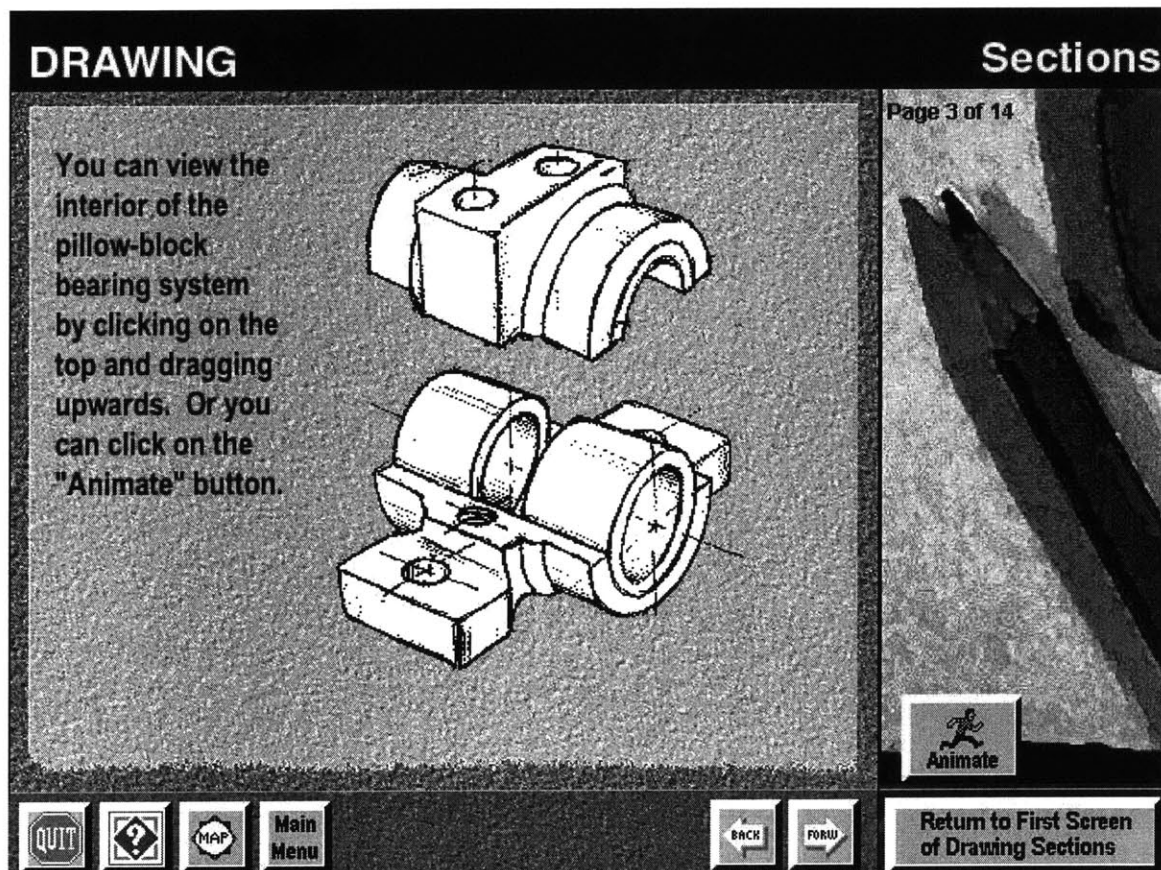


FIGURE 3-4: ANIMATED EXERCISE FROM THE UPDATED DRAWING MODULE.

3.5.6 Dictionary

As implied by the name, the Dictionary was a compilation of technical terms commonly used in mechanical-engineering design. This auxiliary section could be

accessed from the main menu of the Bearings, Cylinders, or Shafts-Rotors chapter. It was also linked directly to specific words throughout the first three chapters. Such words were written in bold blue text to show that clicking on them would open the Dictionary.

Originally, the Dictionary was created as a “pop-up window” on the EDICS CD-ROM. It was designed to be only half the size of the EDICS program window. As a result, the text of each definition was rather small and somewhat hard to read. For the new version, the Dictionary was recreated as a pop-up, but it was made just as large as the main EDICS window, at a resolution of 640x480 pixels. The text of the new Dictionary looked considerably larger than it did on the CD. As an example, the definition for “welding” is shown below.

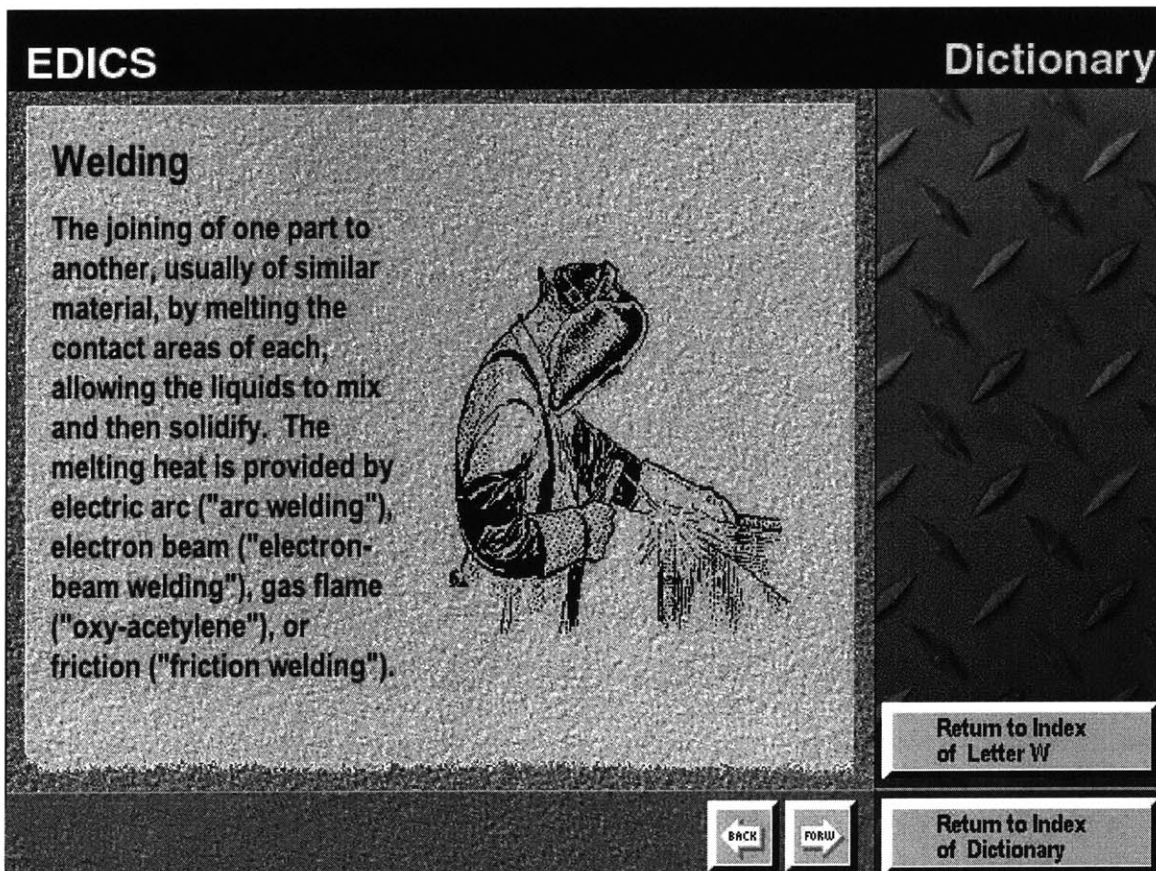


FIGURE 3-5: DEFINITION OF “WELDING” FROM THE UPDATED DICTIONARY.

3.5.7 Help section

Consisting of four topics, this section was designed to give first-time users an introduction to EDICS, as well as tips on how best to navigate through the program. To access it, users could click on the Help button from any page. Like the Dictionary, the Help section was recreated as a pop-up window.

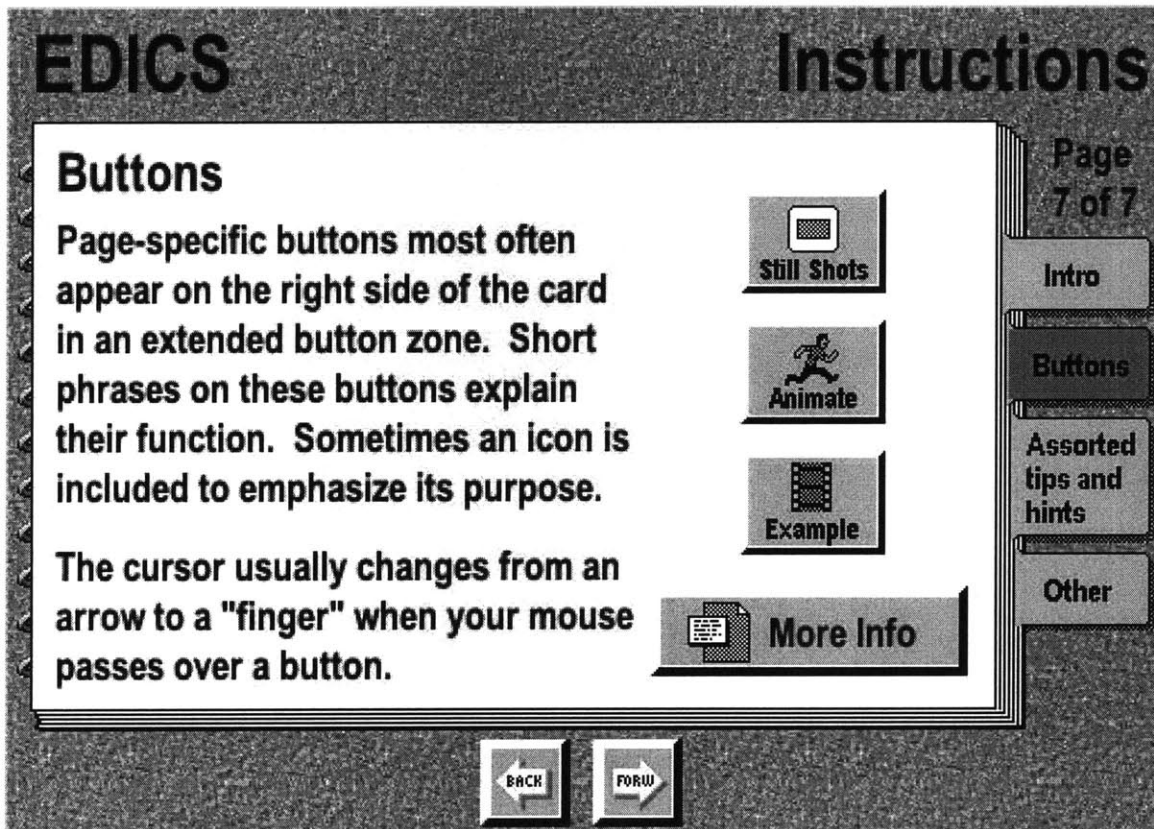


FIGURE 3-6: EXPLANATION OF BUTTONS IN THE UPDATED HELP SECTION.

3.5.8 Map

Clicking on the Map button at any point opened a new window containing a complete outline of EDICS. Each chapter and section were mapped out in considerable detail. With a single click of the mouse, it was possible to access almost any sub-section

of the web modules. Pictured below is the layout for the Bearings chapter.

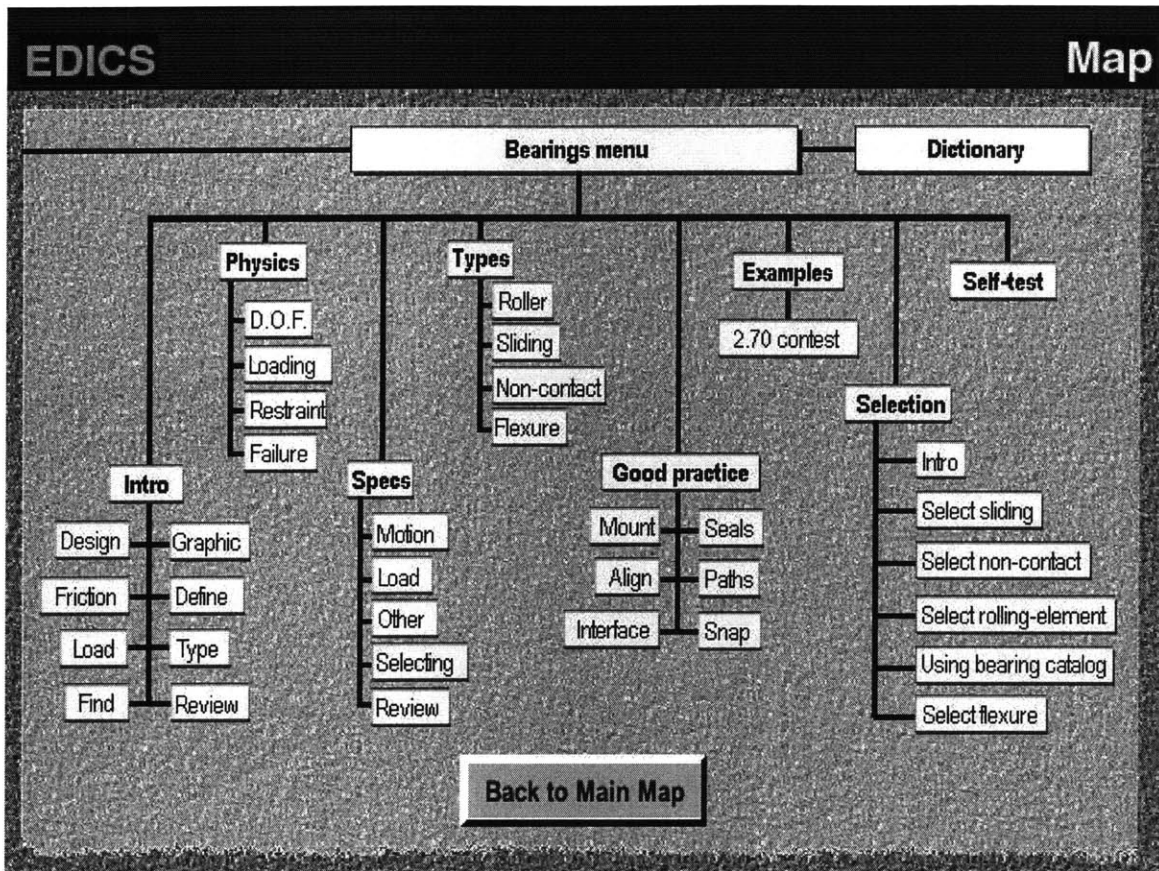


FIGURE 3-7: LAYOUT OF BEARINGS CHAPTER FROM THE UPDATED MAP.

3.6 BETA-TESTING

Upon completion of a section, each Director file was converted to the compact Shockwave format and embedded into an HTML file, for viewing on the world-wide web. Every section of all four chapters was tested for proper playback in Netscape and Internet Explorer. The same was done for the Dictionary, Help, and Map features. This procedure was completed on a variety of computers running both Windows and Macintosh OS. However, the EDICS modules were not tested for use on other operating systems like Linux, or in other browsers like Opera.

Chapter 4

A New Module for EDICS

After conversion of the original chapters of EDICS was complete, a new module on fastening and joining methods was developed. The format was similar to that of the existing modules on bearings, cylinders, and shaft-rotor connections. The principal sections for the new topic were: Introduction; Physics; Design specs; Fastener types; Good practice; Examples; Dictionary; and Credits.

As the name implies, the “Introduction” section provides a broad overview of the chapter. “Physics” covers some common failure modes of fastened parts, to emphasize the idea that the goal of design is to avoid failures. “Design specs” discusses some of the standards by which connections and joints are judged. “Fastener types” gives a list of common (and some not-so-common) fastening and joining methods. The “Good practice” section provides some basic rules for designing joints and choosing the right fastener. “Examples” provides a list of real-world applications where fasteners play an important role. The “Dictionary” gives a reference list of technical terms that are commonly used in mechanical-engineering design. Last, but not least, “Credits” is a compilation of resources that were used while developing this module of EDICS.

4.1 DIGITAL VIDEO

Movie clips were drawn from several sources. Most of the footage was filmed at

MIT by Seichi Tsutsumi. There were videotaped examples showing simple fasteners like nuts and bolts, as well as footage that illustrated more sophisticated joining methods such as arc welding. Some material on rivets was borrowed with permission from a 25-minute videotape named “Blind Fasteners,” which was sponsored jointly by the International Fasteners Institute and the University of North Carolina at Charlotte. In addition, one video on soldering was taken from a laser disk created by the mechanical-engineering department at MIT.

Videotapes were digitized using a Panasonic SVHS deck that was connected directly to the Windows PC. Footage from the laser disk was also digitally captured via a similar hardware configuration. Based on an NTSC standard, the video resolution was set to 352x240 pixels, while a frame rate of 29.97 fps (frames per second) was used. With regard to audio settings, the sampling frequency was set to 44.1 kHz, with 16-bit stereo. The rest of the video-capture process and the subsequent encoding of each movie clip were identical to the procedures described previously in section 3.3.1.

Overall, there were 21 video clips created for the Fasteners module. They were scattered throughout the chapter, but most of them were concentrated in the Examples section. To keep the movies consistent with the ones from previous chapters, all clips were reduced to a resolution of 240x180 pixels before being incorporated into Director. As a result, they were all well under 2 MB in size.

4.2 GRAPHICS AND ANIMATIONS

As before, all images were processed in Adobe Photoshop and stored in one of three file formats: GIF, BMP, or JPG. The first format was reserved for black-and-white pictures, while the latter two were used for color graphics. To create moving animations

though, a separate program called Image Magic was used. It was relatively easy to learn and required less RAM than other comparable software.

4.3 DEVELOPMENT USING DIRECTOR

4.3.1 Introduction

In this section, only minimal familiarity with mechanical joints is assumed. First, some background and basic definitions for fasteners are provided. This is supplemented with examples of well-known applications. Several joining methods for creating permanent joints are also described, along with their subtle differences. A sample page from the Introduction section is shown below.

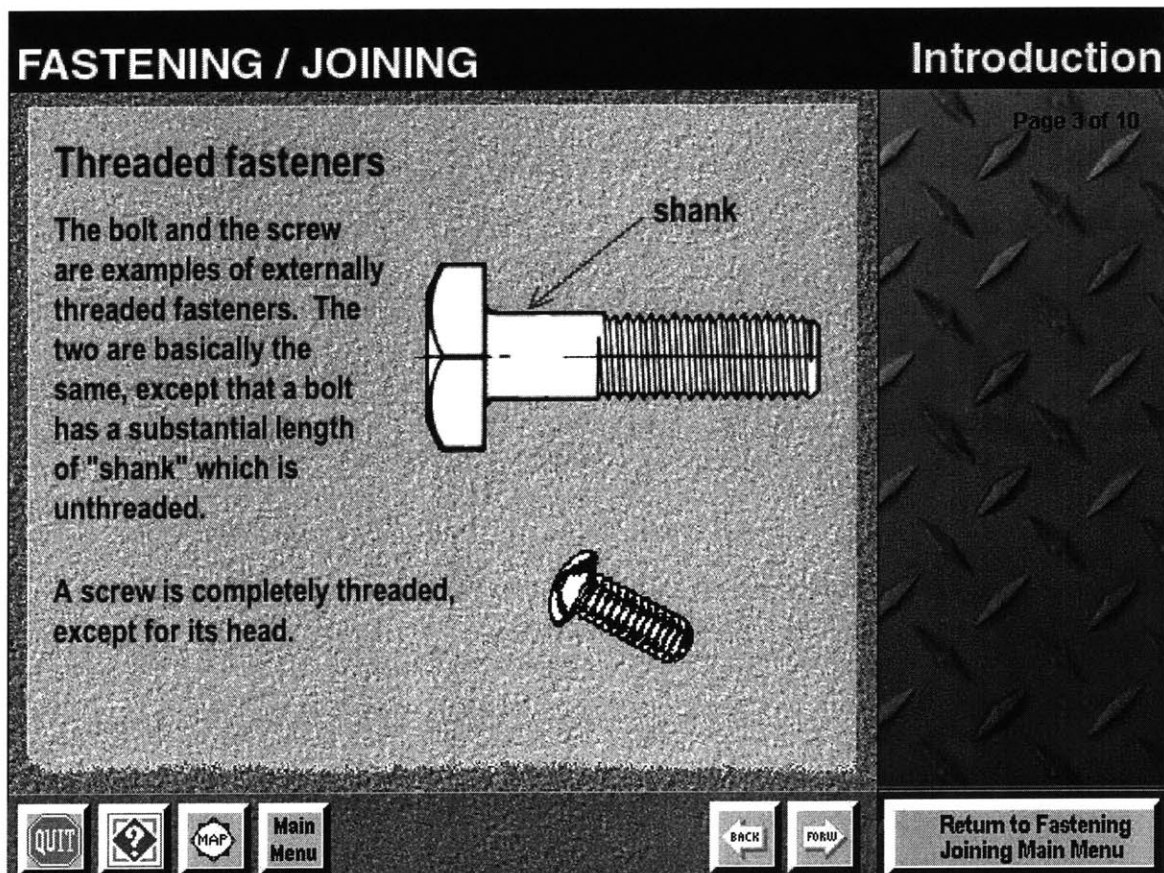


FIGURE 4-1: SAMPLE DEFINITIONS FROM THE INTRODUCTION SECTION.

4.3.2 Physics

Different kinds of failure modes are explained in this section. Some of them apply only to threaded fasteners, while others affect mainly non-threaded ones. Examples of failure modes include fatigue and fretting. Figure 4-2 shows a page from the Physics section.

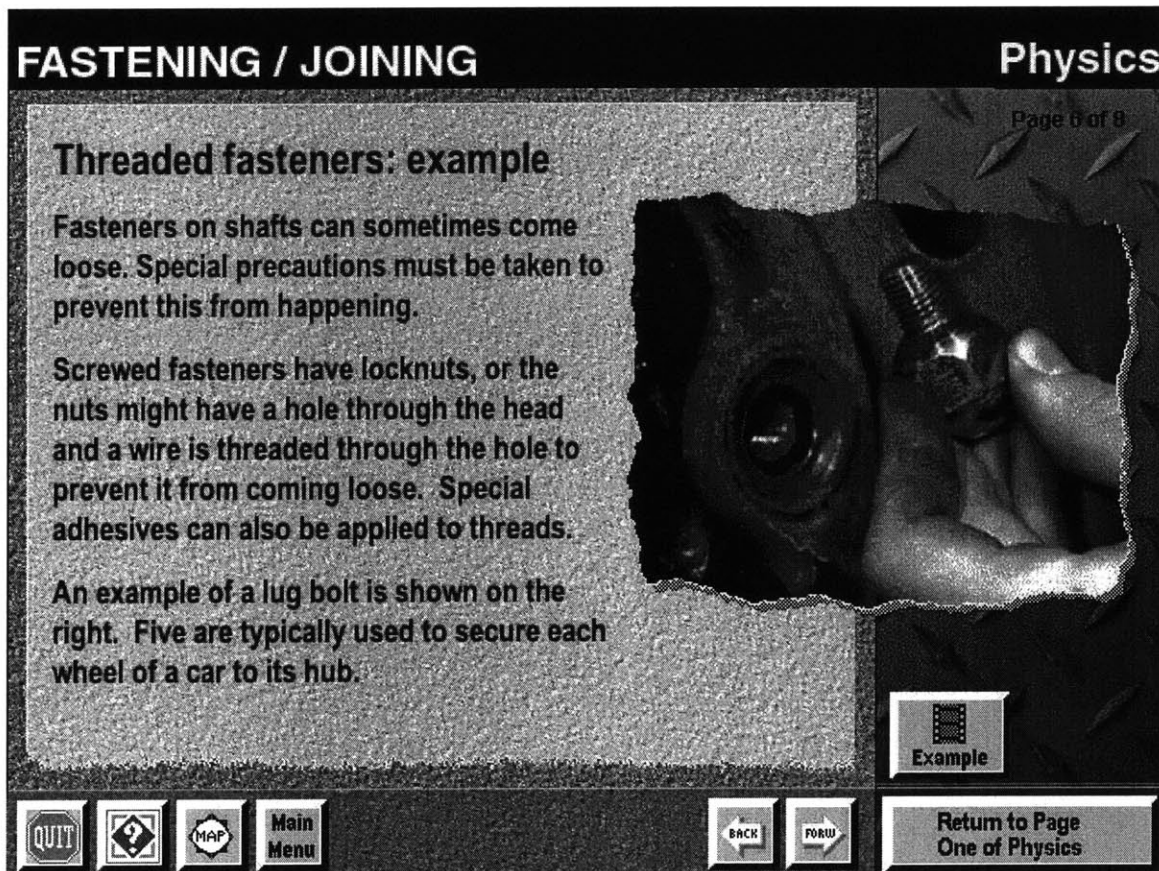


FIGURE 4-2: DISCUSSION OF WHEEL HUBS FROM THE PHYSICS SECTION.

4.3.3 Design specs

This section lists common specifications by which fasteners or joints can be compared against others. In other words, they are typical attributes associated with fastened connections. The most basic specification is the material being used, such as

steel or aluminum. This has a direct effect on mechanical properties, such as ultimate tensile strength and shear strength. Pictured in Figure 4-3 is a sample page from this section that discusses another design specification: hardness.

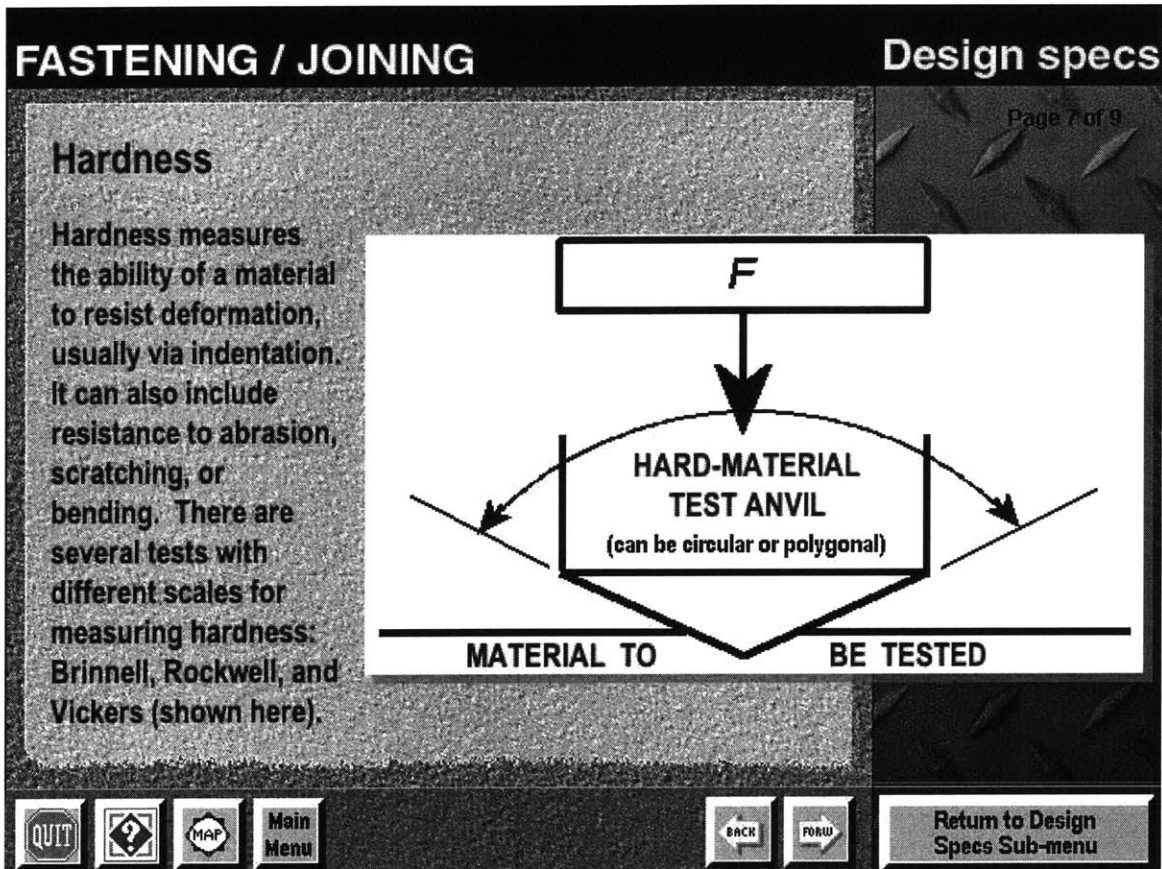


FIGURE 4-3: DISCUSSION OF HARDNESS FROM THE DESIGN SPECS SECTION.

4.3.4 Fastener types

There are many more fastening and joining methods in existence than can possibly be included in a single section of EDICS. Therefore, the goal is to emphasize breadth, not depth.

Most methods of fastening and joining mechanical components fall into one of three categories, based on how permanent the resulting connection is. Nuts and bolts are

considered non-permanent, as are studs, washers, and snap rings. These fasteners can be manually removed with relative ease. Welding and brazing are joining methods which are used only when a permanent joint is desired. No disassembly is expected for such connections. Between those two extremes is a class of semi-permanent fasteners, such as rivets and pins, which can be removed. However, doing so would require greater effort than simply unscrewing a few nuts and bolts. Soldering also belongs to this intermediate group. With these three categories in mind, various fastening and joining methods are discussed in order of increasing permanence. For instance, a description of gas-tungsten arc welding is shown in Figure 4-4.

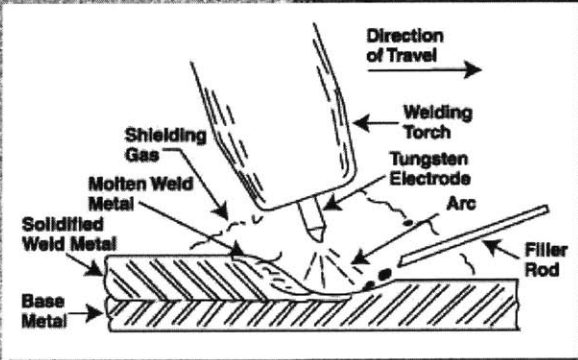
FASTENING / JOINING **Fastener types**

Page 51 of 56

Permanent: gas-tungsten arc welding (GTAW)

This arc-welding process can be used to join both ferrous and non-ferrous metals. First, an arc is struck between a tungsten electrode and the work-piece. The weld is then shielded from the atmosphere by a gas, usually helium, that forms an envelope around the weld area.

GTAW is generally considered to be the cleanest and most precise method of welding. It is also known as TIG, or tungsten inert-gas, welding.



The diagram illustrates the GTAW process. A tungsten electrode is held by a welding torch and is positioned to create an arc with the base metal. Shielding gas flows around the electrode to protect it from the atmosphere. As the torch moves in the direction of travel, it leaves behind molten weld metal, which then solidifies into weld metal. A filler rod is used to add additional material to the weld.

Example

QUIT **MAP** **Main Menu** **BACK** **FORW** **Return to Fastener Types Sub-menu**

FIGURE 4-4: DESCRIPTION OF GTAW / TIG FROM THE TYPES SECTION.

4.3.5 Good practice

Practical rules of thumb are given to help novice designers avoid some common errors. For example, using snap rings on shafts can be a tricky method for beginners. A list of tips for dealing with those fasteners is included. The issue of when to use blind rivets is also discussed. Other advice given in this section include safety rules that should be followed when welding. In Figure 4-5 below, some tips are given for creating a well-brazed joint.

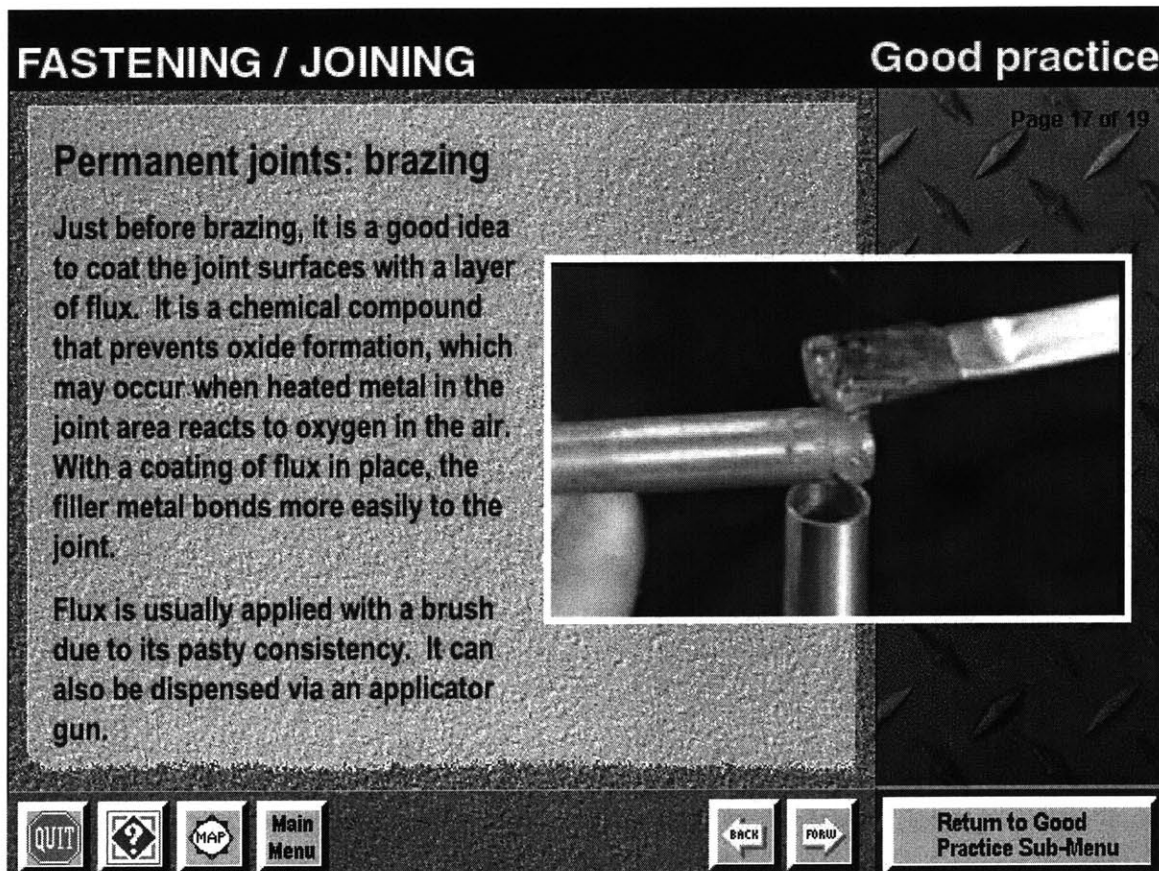


FIGURE 4-5: BRAZING TIPS FROM THE GOOD PRACTICE SECTION.

4.3.6 Examples

To shed some light on the critical role that fasteners play, examples of

connections and joints are drawn from common real-world applications. For instance, lawnmowers, bikes, and aircraft are discussed from an assembly point-of-view. Many of the examples are accompanied by a video clip too. In Figure 4-6, the importance of brazed joints is illustrated.

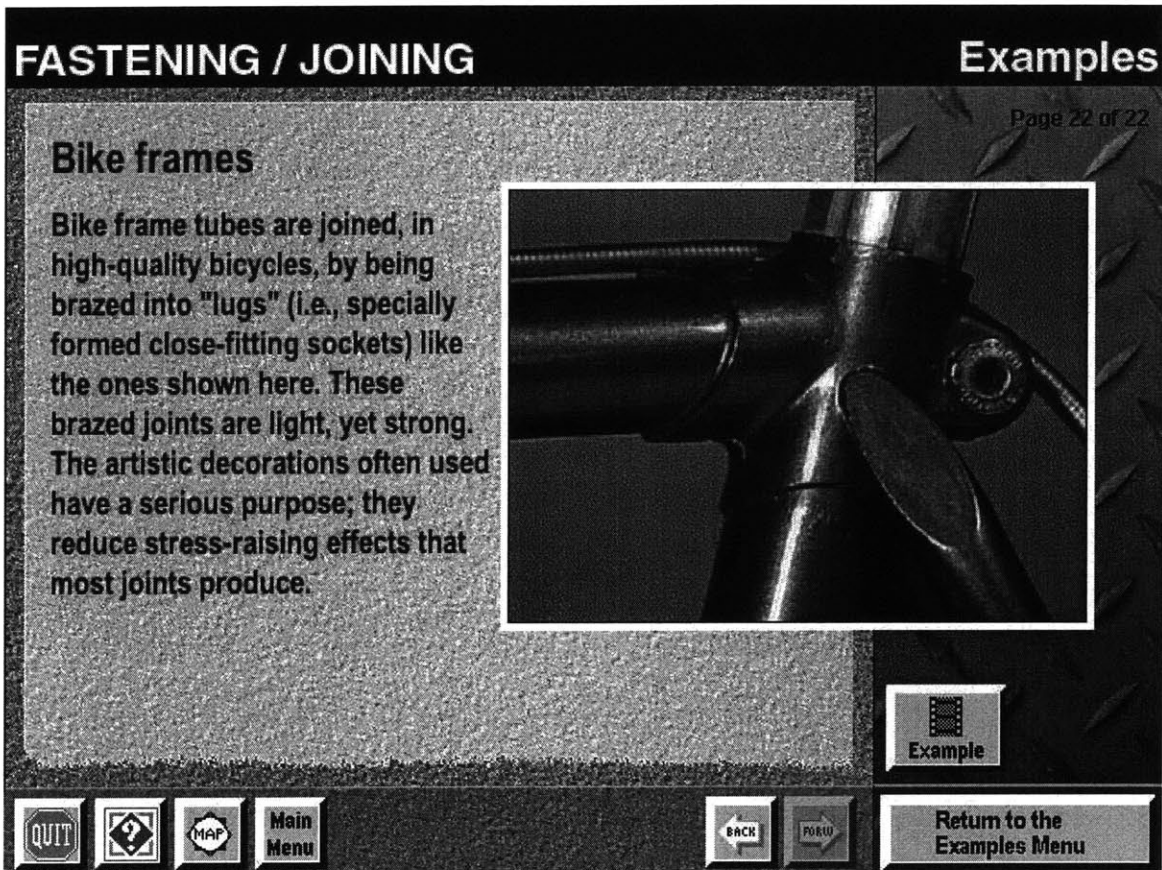


FIGURE 4-6: DISCUSSION OF BIKE FRAMES FROM THE EXAMPLES SECTION.

4.3.7 Dictionary

The Dictionary lists some of the terms used to describe mechanical assemblies, including definitions for a wide variety of fasteners. For example, an illustrated description of a “tapered pin” is shown in Figure 4-7. Different types of welding are also defined, along with brazing. As before, the Dictionary is designed to appear as a pop-up

window. It is larger than any other section of this module, although the Types section also has a considerable amount of content.

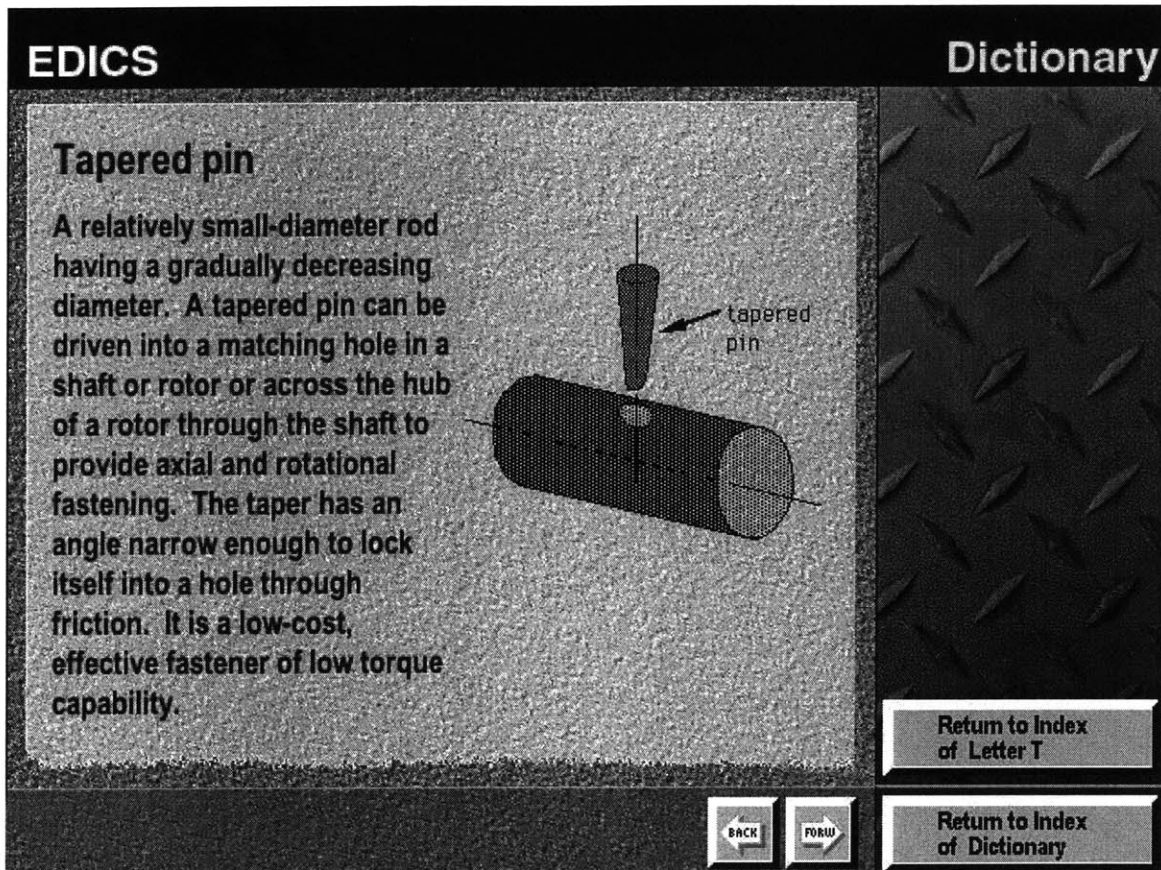


FIGURE 4-7: DEFINITION OF “TAPERED PIN” FROM THE DICTIONARY.

4.3.8 Credits

This section provides a compilation of resources that were consulted while creating this module of EDICS. Relevant publications and websites are listed. In addition, the video sources for all movie clips are cited. This compilation may be helpful for users hoping to find more information about a particular fastening or joining method. For example, a comprehensive list of websites is shown in Figure 4-8.

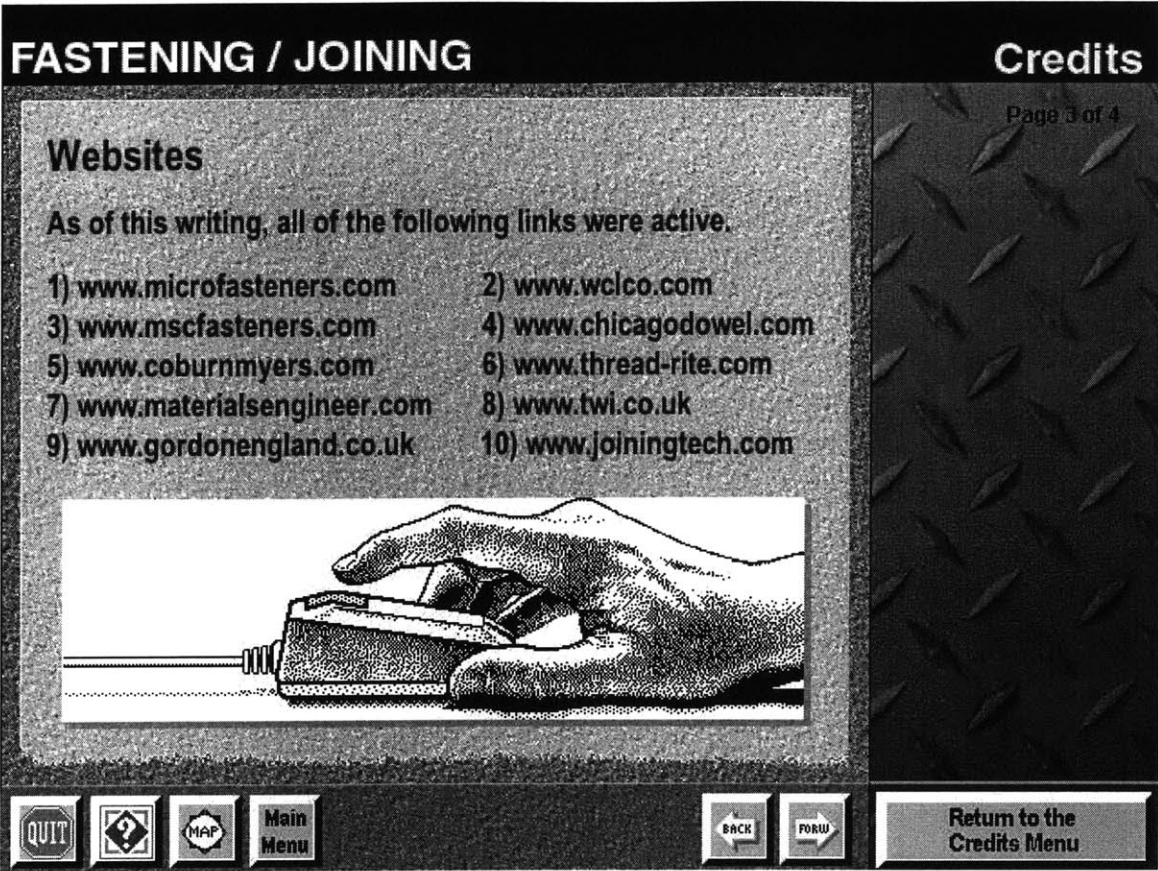


FIGURE 4-8: LIST OF WEBSITES FROM THE CREDITS SECTION.

4.4 BETA-TESTING

As development of the module progressed, each section was tested for compatibility with multiple versions of both Netscape and Internet Explorer. All supplementary materials, e.g. movie clips and animations, played back properly. Even on a dial-up modem, the videos were accessible at a decent speed. This web-based testing procedure was performed on several computers, some running Windows and others using Mac OS. Due to time constraints though, playback was not tested on Linux or other operating systems. No other web browsers were used either. After testing was done, the EDICS Map was updated to include a detailed layout of the Fastening-Joining module.

Chapter 5

Conclusions and Recommendations

The Macintosh-only EDICS CD-ROM was converted to a web-based format. A new chapter on fastening and joining methods was also developed. This revamped version of EDICS can be viewed on machines running either Microsoft OS (Windows 98 or higher), or Macintosh OS (8.1 or higher). It is compatible with both Netscape and IE.

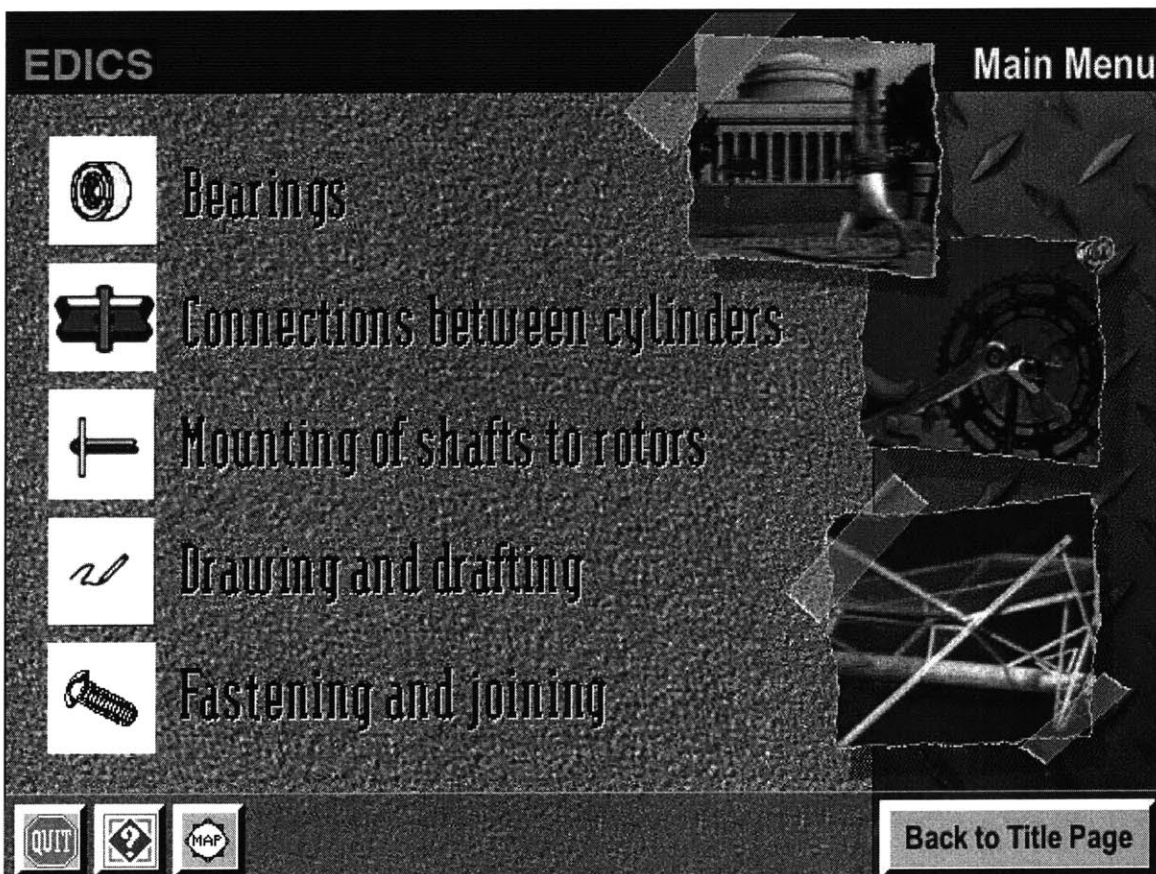


FIGURE 5-1: MAIN MENU OF THE REVAMPED EDICS.

Earlier in EDICS development, the team decided that running it on “Athena” (MIT’s internal “web”) was not desirable because there was so long a delay between one screen and the next that users could get frustrated. The accelerated evolution of hardware and software since then has resulted in there being little or no lag time when viewing successive pages of a module. With no apparent difference in timing between web-based and CD-based operation, on-line distribution and use of EDICS are quite feasible.

In terms of scope, EDICS covers several topics that are somewhat troublesome for novice designers to learn. However, there are still many areas of design that require coverage. New chapters on additional design topics, such as material selection and power transmission, should be added.

Future work should include assessment of EDICS using student subjects drawn from undergraduate mechanical-engineering design courses and also introductory freshmen programs. Besides testing the effectiveness of EDICS, areas of software development that need improvement can be identified. In addition, creating another stand-alone CD-ROM version of EDICS, similar to its predecessor, would be a plus. An alternative would be to place the modules on DVD instead. Doing so would guarantee much greater storage space for the videos. As a result, all movie clips could be stored at a higher resolution, such as 352x240 or 640x480 pixels.

Another possibility is to evaluate the usability of EDICS by handicapped people, such as those who are deaf, blind, or wheelchair-bound. Only recently have software developers and webpage designers addressed or considered accessibility of finished products for the disabled [Ludi 02]. Making closed captions or subtitles available for the video clips would be a first step in that direction.

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Appendix A

Outline of EDICS

The following links contain all the content for the web-based version of EDICS.

* Main Menu

<http://web.mit.edu/mtyung/www/EDICS/MainMenu.htm>

* Bearings Module

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part01.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part02.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part03.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part04.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part05.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part06.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part07.htm

http://web.mit.edu/mtyung/www/EDICS/Bearings_Part09.htm

<http://web.mit.edu/mtyung/www/EDICS/Timken.htm>

* Cylinders Module

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part01.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part02.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part03.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part04.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part05.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part06.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part07.htm

http://web.mit.edu/mtyung/www/EDICS/Cylinders_Part09.htm

* Shafts-Rotors Module

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part01.htm

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part02.htm

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part03.htm

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part04.htm

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part05.htm

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part06.htm

http://web.mit.edu/mtyung/www/EDICS/ShaftsRotors_Part08.htm

- * Drawing Module
<http://web.mit.edu/mtyung/www/EDICS/Drawing.htm>

- * Fasteners Module
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part01.htm
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part02.htm
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part03.htm
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part04.htm
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part05.htm
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part06.htm
http://web.mit.edu/mtyung/www/EDICS/Fasteners_Part08.htm

- * Map
<http://web.mit.edu/mtyung/www/EDICS/Map.htm>

- * Dictionary
<http://web.mit.edu/mtyung/www/EDICS/Dictionary.htm>

- * Help Section
<http://web.mit.edu/mtyung/www/EDICS/HelpSection.htm>

Appendix B

Scripts Used in EDICS

Here is a list of scripts that were created specifically for the EDICS web modules.

All of them were written in Lingo, the programming language native to Director.

B.1 FIND THE BEARINGS

The following is the movie script for the exercise “Find the bearings” from the Introduction section of the Bearings chapter.

```
global clicks1, clicks2, clicks3, clicks4  
global a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, xx, yy
```

```
on startMovie
```

```
clicks1 = 0 -- initialize all counters  
clicks2 = 0  
clicks3 = 0  
clicks4 = 0
```

```
a = 0 -- initialize all variables  
b = 0  
c = 0  
d = 0  
e = 0  
f = 0  
g = 0  
h = 0  
i = 0  
j = 0  
k = 0  
l = 0  
m = 0
```



```
n = 0
o = 0
p = 0
q = 0
r = 0
s = 0
t = 0
u = 0
v = 0
w = 0
xx = 0
yy = 0
```

```
end startMovie
```

```
on enterFrame me
```

```
case the frame of
```

```
-- Frames for UPPER-LEFT QUADRANT --
-- 8 Bearings: a, b, c, d, e, f, g, h --
```

```
173:
```

```
a = a + 1
if a = 1 then
  clicks1 = clicks1 + 1
  if clicks1 = 8 then
    go to frame 175
    a = 0 -- resets the counter for upper-left area
    b = 0
    c = 0
    d = 0
    e = 0
    f = 0
    g = 0
    h = 0
    clicks1 = 0
  end if
end if
```

```
176:
```

```
b = b + 1
if b = 1 then
  clicks1 = clicks1 + 1
  if clicks1 = 8 then
    go to frame 178
```

```
a = 0 -- resets the counter for upper-left area
b = 0
c = 0
d = 0
e = 0
f = 0
g = 0
h = 0
clicks1 = 0
end if
end if
```

179:

```
c = c + 1
if c = 1 then
  clicks1 = clicks1 + 1
  if clicks1 = 8 then
    go to frame 181
    a = 0 -- resets the counter for upper-left area
    b = 0
    c = 0
    d = 0
    e = 0
    f = 0
    g = 0
    h = 0
    clicks1 = 0
  end if
end if
```

182:

```
d = d + 1
if d = 1 then
  clicks1 = clicks1 + 1
  if clicks1 = 8 then
    go to frame 184
    a = 0 -- resets the counter for upper-left area
    b = 0
    c = 0
    d = 0
    e = 0
    f = 0
    g = 0
    h = 0
    clicks1 = 0
  end if
```

end if

185:

e = e + 1

if e = 1 then

clicks1 = clicks1 + 1

if clicks1 = 8 then

go to frame 187

a = 0 -- resets the counter for upper-left area

b = 0

c = 0

d = 0

e = 0

f = 0

g = 0

h = 0

clicks1 = 0

end if

end if

188:

f = f + 1

if f = 1 then

clicks1 = clicks1 + 1

if clicks1 = 8 then

go to frame 190

a = 0 -- resets the counter for upper-left area

b = 0

c = 0

d = 0

e = 0

f = 0

g = 0

h = 0

clicks1 = 0

end if

end if

191:

g = g + 1

if g = 1 then

clicks1 = clicks1 + 1

if clicks1 = 8 then

go to frame 193

a = 0 -- resets the counter for upper-left area

b = 0

```
c = 0
d = 0
e = 0
f = 0
g = 0
h = 0
clicks1 = 0
end if
end if
```

194:

```
h = h + 1
if h = 1 then
clicks1 = clicks1 + 1
if clicks1 = 8 then
go to frame 196
a = 0 -- resets the counter for upper-left area
b = 0
c = 0
d = 0
e = 0
f = 0
g = 0
h = 0
clicks1 = 0
end if
end if
```

-- Frames for UPPER-RIGHT QUADRANT --
-- 6 Bearings: i, j, k, l, m, n --

218:

```
i = i + 1
if i = 1 then
clicks2 = clicks2 + 1
if clicks2 = 6 then
go to frame 220
i = 0 -- resets the counter for upper-right area
j = 0
k = 0
l = 0
m = 0
n = 0
clicks2 = 0
end if
end if
```

222:

```
j = j + 1
if j = 1 then
  clicks2 = clicks2 + 1
  if clicks2 = 6 then
    go to frame 224
    i = 0 -- resets the counter for upper-right area
    j = 0
    k = 0
    l = 0
    m = 0
    n = 0
    clicks2 = 0
  end if
end if
```

226:

```
k = k + 1
if k = 1 then
  clicks2 = clicks2 + 1
  if clicks2 = 6 then
    go to frame 228
    i = 0 -- resets the counter for upper-right area
    j = 0
    k = 0
    l = 0
    m = 0
    n = 0
    clicks2 = 0
  end if
end if
```

230:

```
l = l + 1
if l = 1 then
  clicks2 = clicks2 + 1
  if clicks2 = 6 then
    go to frame 232
    i = 0 -- resets the counter for upper-right area
    j = 0
    k = 0
    l = 0
    m = 0
    n = 0
    clicks2 = 0
  end if
end if
```

```
end if  
end if
```

234:

```
m = m + 1  
if m = 1 then  
  clicks2 = clicks2 + 1  
  if clicks2 = 6 then  
    go to frame 236  
    i = 0 -- resets the counter for upper-right area  
    j = 0  
    k = 0  
    l = 0  
    m = 0  
    n = 0  
    clicks2 = 0  
  end if  
end if
```

238:

```
n = n + 1  
if n = 1 then  
  clicks2 = clicks2 + 1  
  if clicks2 = 6 then  
    go to frame 240  
    i = 0 -- resets the counter for upper-right area  
    j = 0  
    k = 0  
    l = 0  
    m = 0  
    n = 0  
    clicks2 = 0  
  end if  
end if
```

```
-- Frames for LOWER-LEFT QUADRANT --  
-- 9 Bearings: o, p, q, r, s, t, u, v, w --
```

263:

```
o = o + 1  
if o = 1 then  
  clicks3 = clicks3 + 1  
  if clicks3 = 9 then  
    go to frame 265  
    o = 0 -- resets the counter for lower-left area  
    p = 0
```

```
q = 0
r = 0
s = 0
t = 0
u = 0
v = 0
w = 0
clicks3 = 0
end if
end if
```

267:

```
p = p + 1
if p = 1 then
clicks3 = clicks3 + 1
if clicks3 = 9 then
go to frame 269
o = 0 -- resets the counter for lower-left area
p = 0
q = 0
r = 0
s = 0
t = 0
u = 0
v = 0
w = 0
clicks3 = 0
end if
end if
```

271:

```
q = q + 1
if q = 1 then
clicks3 = clicks3 + 1
if clicks3 = 9 then
go to frame 273
o = 0 -- resets the counter for lower-left area
p = 0
q = 0
r = 0
s = 0
t = 0
u = 0
v = 0
w = 0
clicks3 = 0
```

```
end if  
end if
```

275:

```
r = r + 1  
if r = 1 then  
  clicks3 = clicks3 + 1  
  if clicks3 = 9 then  
    go to frame 277  
    o = 0 -- resets the counter for lower-left area  
    p = 0  
    q = 0  
    r = 0  
    s = 0  
    t = 0  
    u = 0  
    v = 0  
    w = 0  
    clicks3 = 0  
  end if  
end if
```

279:

```
s = s + 1  
if s = 1 then  
  clicks3 = clicks3 + 1  
  if clicks3 = 9 then  
    go to frame 281  
    o = 0 -- resets the counter for lower-left area  
    p = 0  
    q = 0  
    r = 0  
    s = 0  
    t = 0  
    u = 0  
    v = 0  
    w = 0  
    clicks3 = 0  
  end if  
end if
```

283:

```
t = t + 1  
if t = 1 then  
  clicks3 = clicks3 + 1  
  if clicks3 = 9 then
```



```
go to frame 285
o = 0 -- resets the counter for lower-left area
p = 0
q = 0
r = 0
s = 0
t = 0
u = 0
v = 0
w = 0
clicks3 = 0
end if
end if
```

287:

```
u = u + 1
if u = 1 then
clicks3 = clicks3 + 1
if clicks3 = 9 then
go to frame 289
o = 0 -- resets the counter for lower-left area
p = 0
q = 0
r = 0
s = 0
t = 0
u = 0
v = 0
w = 0
clicks3 = 0
end if
end if
```

291:

```
v = v + 1
if v = 1 then
clicks3 = clicks3 + 1
if clicks3 = 9 then
go to frame 293
o = 0 -- resets the counter for lower-left area
p = 0
q = 0
r = 0
s = 0
t = 0
u = 0
```

```
v = 0
w = 0
clicks3 = 0
end if
end if
```

295:

```
w = w + 1
if w = 1 then
  clicks3 = clicks3 + 1
  if clicks3 = 9 then
    go to frame 297
    o = 0 -- resets the counter for lower-left area
    p = 0
    q = 0
    r = 0
    s = 0
    t = 0
    u = 0
    v = 0
    w = 0
    clicks3 = 0
  end if
end if
```

```
-- Frames for LOWER-RIGHT QUADRANT --
-- 2 Bearings: xx, yy --
```

310:

```
xx = xx + 1
if xx = 1 then
  clicks4 = clicks4 + 1
  if clicks4 = 2 then
    go to frame 312
    xx = 0 -- resets counter for lower-right area
    yy = 0
    clicks4 = 0
  end if
end if
```

314:

```
yy = yy + 1
if yy = 1 then
  clicks4 = clicks4 + 1
  if clicks4 = 2 then
    go to frame 316
```

```
        xx = 0 -- resets counter for lower-right area
        yy = 0
        clicks4 = 0
    end if
end if

end case

end enterFrame
```

```
on exitFrame me
```

```
if clicks1 = 8 then
    set a = 0
    set b = 0
    set c = 0
    set d = 0
    set e = 0
    set f = 0
    set g = 0
    set h = 0
    set clicks1 = 0
else
    if clicks2 = 6 then
        set i = 0
        set j = 0
        set k = 0
        set l = 0
        set m = 0
        set n = 0
        set clicks2 = 0
    else
        if clicks3 = 9 then
            set o = 0
            set p = 0
            set q = 0
            set r = 0
            set s = 0
            set t = 0
            set u = 0
            set v = 0
            set w = 0
            set clicks3 = 0
        else
            if clicks4 = 2 then
```

```
        set xx = 0
        set yy = 0
        set clicks4 = 0
    end if
end if
end if
end if
```

```
end exitFrame
```

B.2 MAIN MENU

The following script returns the user to the main menu of EDICS.

```
on mouseUp
    gotoNetPage("http://web.mit.edu/mtyung/www/EDICS/MainMenu.htm")
end mouseUp
```

B.3 MAP

This script gives the user access to the Map. It appears as a pop-up window.

```
on mouseUp
    gotoNetPage("http://web.mit.edu/mtyung/www/EDICS/Map.htm", "_new")
end mouseUp
```

B.4 DICTIONARY

The Dictionary is accessible via this script.

```
on mouseUp
    gotoNetPage("http://web.mit.edu/mtyung/www/EDICS/Dictionary.htm", "_new")
end mouseUp
```

B.5 HELP SECTION

The following script opens a pop-up window for the Help section.

```
on mouseUp
```

```
gotoNetPage("http://web.mit.edu/mtyung/www/EDICS/HelpSection.htm", "_new")  
end mouseUp
```

B.6 QUIT

Exiting EDICS is made possible by execution of this script.

```
on mouseUp  
gotoNetPage("http://web.mit.edu/mtyung/www/EDICS/")  
end mouseUp
```

B.7 TIMKEN DATABASE

This script gives the user access to a database that contains information from a bearing catalog. It was borrowed with permission from Timken.

```
on mouseUp  
gotoNetPage("http://web.mit.edu/mtyung/www/EDICS/Timken.htm", "_new")  
end mouseUp
```

Appendix C

Glossary

This section provides definitions for most of the technical jargon used in this thesis.

-- A --

Adobe

Company that created programs like Acrobat, Photoshop, and Premiere.

animated gif

A popular format for simple graphic animations, compatible with both web browsers Netscape and Internet Explorer. Does not support audio though.

AVI

Standard file extension used by Video-for-Windows files.

-- B --

bit rate

Measures the rate of storage for digital data. Usually refers to audio and video files. In general, the higher the bit rate used, the better the quality of a recording.

-- C --

codec

An algorithm used to compress or decompress digital files, usually audio or video recordings.

-- D --

digitize

To digitally record or “capture” video that was originally stored in an analog format, e.g. VHS or laser disk.

Director

An advanced authoring tool used to develop multimedia presentations for delivery over the web or as stand-alone applications. Works on both Windows and Macintosh operating systems. Released by Macromedia.

-- E --

encode

To compress a digitally recorded audio or video file. May also include converting the original file to another digital format.

-- F --

Flash

An authoring tool used to design multimedia presentations for delivery exclusively over the web. Works on both Windows and Mac operating systems. Released by Macromedia.

fps

Standard abbreviation for “frames per second.” Used to measure frame rate.

frame rate

Rate at which video and audio data are digitally stored. Usually measured in terms of frames per second. The higher the frame rate, the more fluid the video or audio playback.

freeware

A term referring to software that is freely available for anyone to download from the web, without paying any fee for use of the product.

-- G --

GB

Standard abbreviation for “gigabytes.” Common unit of measurement for the amount of digital data that can be stored on a hard-disk drive. For reference, 1 GB = 1000 MB.

GHz

Standard abbreviation for “gigahertz.” Measures the speed of the CPU or processor in a computer. For comparison, 1 GHz = 1000 MHz.

-- H --

HTML

Standard abbreviation for “Hyper-Text Markup Language.” Webpages are usually written in this code.

HyperCard

An authoring tool that uses “cards” and “stacks” to build programs. Works only on Macintosh systems. Released by Apple.

-- I --

Intel

Manufacturer of the Pentium-series processors.

Internet Explorer

A commonly-used web browser, sometimes abbreviated as IE. Released by Microsoft.

-- J --

Java

An advanced programming language used to write object-oriented, modular programs. Small programs called “applets” are written in Java.

-- K --

kbps

Standard abbreviation for “kilobits per second.” Used to measure audio or video bit rate.

-- L --

Ligos LSX-MPEG Encoder

Program that can convert video files from AVI to MPG format.

Lingo

The scripting language native to Director.

Linux

Non-commercial operating system distributed by Red Hat, Caldera, MandrakeSoft, and others.

-- M --

Macromedia

Company that created programs like Director, Flash, Dreamweaver, Fireworks, and Authorware.

MB

Standard abbreviation for “megabytes.” Common unit of measurement for the amount of digital data stored within a computer file.

MHz

Standard abbreviation for “megahertz.” Measures the speed of the CPU or processor in a computer. The higher the MHz, the faster the machine.

MOV

Standard file extension for QuickTime video files.

MPEG-1

A video-file format developed by the Motion Picture Experts Group.

MPG

Standard file extension for MPEG-1 video files.

-- N --

Netscape

A commonly-used web browser, sometimes abbreviated as NS. Released by the company of the same name.

-- O --

OS

Standard abbreviation for “operating system.” Examples include MacOS X and Windows 2000.

-- P --

PC

Standard abbreviation for “personal computer.” Generally refers to computers using a processor manufactured by Intel or AMD. Term originally coined by IBM.

Photoshop

An image-editing program that supports a wide range of graphic formats, such as BMP, GIF, JPG, PNG, PSD, and TIF. Released by Adobe.

pixel

Commonly used to measure the width and height of the viewing area for a computer monitor or TV screen. In general, 72 pixels make up one inch.

pixellation

The effect of highly compressed video, where image quality is sacrificed and moving images appear “blocky” along the edges.

platform

In terms of technical jargon, refers to a computer architecture that uses a particular operating system.

Premiere

An advanced video-editing program that supports a wide range of audio and video formats. Released by Adobe.

-- Q --

QuickTime

A video-file format that originated on Apple Macintosh computers. Currently supported on both Windows and Mac operating systems.

-- R --

RAM

Standard abbreviation for “random-access memory.” Measures the amount of memory storage available for running programs on a computer. The greater the amount of RAM, the higher the number of applications that can run simultaneously on a computer.

resolution

In terms of digital video, refers to the on-screen dimensions (width and height) of a movie file. Usually measured in pixels, e.g. 640x480.

-- S --

Shockwave

Format in which most Director files are delivered over the web. Nothing more than a highly compressed version of the original Director file. Although Shockwave retains all of the information necessary to present the original content, it is impossible to edit any part of it. Hence, Shockwave is a safe way to deliver multimedia presentations on-line due to its built-in copy-protection.

SuperCard

An advanced authoring tool similar to HyperCard, but with more features. Works only on Macintosh systems. Released by IncWell DMG, Ltd.

-- T --

TMPEnc

A video-editing program that produces specifically MPG video files.

-- U --

-- V --

Virtual Dub

A video-editing program that can process video files of AVI and MPG format, as well as some audio files.

-- W --

-- X --

XingMPEG Encoder

Program that can encode files in MPG format.

-- Y --

-- Z --