THE ENGINEERING DESIGN GRAPHICS Journal

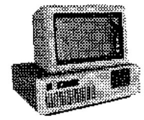
Spring 1988 Volume 52 Number 2

ENGINEERING DESIGN GRAPHICS DIVISION

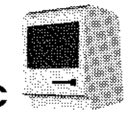
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

PRO 3D

3-D CAD and Illustration



Pro3D/PC Pro3D/Mac



PRO3D/PC™ INCLUDES MICROSOFT® WINDOWS STANDALONE RUNTIME • FULL COLOR

Power

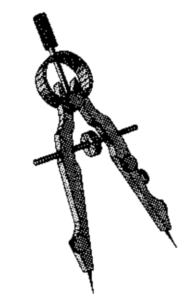
Profiler™
- Create irregular objects by manipulating individual cross-sections of any thickness
- Continuous display of 3-D wire-frame preview

Lathe
- Create radially symmetric objects from a 2-D cross-section
- 180 smoothness settings

Full Merging
- Union, Subtraction, Intersection

Full Drawing and Editing Aids
- Eight mirrors for symmetrical drawing
- Create high resolution concave or convex curves
- Color or shade entire object or individual polygons
- Choose triangular or rectangular polygons
- Edit single or multiple points
- Save Power Tool Outline files for later editing
- Fully variable ambient and direct lighting

Precision

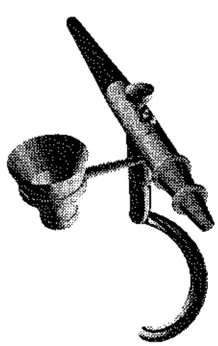


Compass
by G. Brandenberg

Dimensioning
- Design objects using either relative or absolute dimensions
- Continuous read-out of position while moving object in 3-D space
- Measure relative positions of objects
- Measure current size of object
- Define any scale to suit your purpose, e.g., inches, centimeters, one tenth scales

Automatic Alignment
- Align single objects, or groups of objects, in any of 729 different 3-D arrangements- Line up tops, bottoms, left or right sides, vertical or horizontal centers of objects or object groups in any combination
- Absolute alignment: Align centers of objects to either the vertical or horizontal axis passing through the center of the universe

Production



Airbrush
by D. Skover

Printing
- Three bit-map options for various dot matrix printers
- Compatible with most popular laser printers
- Takes full advantage of higher resolution laser printers such as the Linotronic 300™

High Resolution Output Features
- Up to 1000 gray shades available
- 100 levels of contrast
- Fully adjustable scaling and page placement in inches, millimeters, and picas

Export Capabilities
- Save PICT and Paint files for use with painting, drawing, and drafting software
- Save page description files, i.e., PostScript™, for use with high resolution page layout systems
- Full file compatibility between Pro3D/Mac and Pro3D/PC
- IGES 3.0 and ASCII translators optional

For more information, contact:
Enabling Technologies, Inc.
600 South Dearborn, Suite 1304
Chicago, Illinois 60605
312/427-0408

See your dealer for more information.

Distributed to the the trade by the **Ashton-Tate Publishing Group.**

ISSN 0046-2012

PUBLICATION BOARD

CALENDAR OF EVENTS

ASEE ANNUAL CONFERENCE
1988 PORTLAND hosted by University of Portland

EDGD MIDYEAR MEETINGS
1988 EVANSVILLE hosted by The University of Southern Indiana
1989 TUSCALOOSA hosted by The Universityof Alabama

The Engineering Design Graphics Journal is published one Volume per year, three Numbers per Volume in Winter, Spring, and Fall by the Engineering Design Graphics Division of the American Society for Engineering Education, for teachers and practitioners of Engineering, Computer, Design, and Technical Graphics. The views and opinions expressed by the individual authors do not necessarily reflect the editorial policy of The Engineering Design Graphics Division or of the American Society for Engineering Education. The editors make a reasonable effort to verify the technical content of the material published; however, the final responsibility for opinions and technical accuracy rests entirely upon the author.

SUBSCRIPTION RATES

YEARLY RATES U.S.	
ASEE Member	$3.00
Non-Member	$6.00
Canada, Mexico	$10.00
Foreign Subscribers	$20.00
SINGLE COPY RATES	
U.S.	
ASEE MEMBER	$1.50
Non-Member	$2.50
Canada, Mexico	$3.50
Foreign Subscribers	$7.00

All fees are payable to the Engineering Design Graphics Journal at: The Engineering Design Graphics Journal, Department of Engineering Graphics, The Ohio State University, 2070 Neil Avenue, Columbus, OH 43210. Back issues are available at single copy rates (prepaid) from the circulation manager and are limited in general to numbers published within the past six years. Subscription expiration date appears in the upper right corner of the mailing label as follows: ASEE/EDGD member is the same month/year as ASEE dues e.g. 6/86; all others last issue paid e.g. W86 for Winter 1986. Claims for missing issues must be submitted to the Circulation Manager within a six-month period following the month of publication: February for Winter, May for Spring, and November for Autumn.

OBJECTIVES OF THE JOURNAL

The objectives of The Journal are:

1. To publish articles of interest to teachers and practitioners of Engineering Graphics, Computer Graphics, and subjects allied to the fundamentals of engineering graphics education and graphic technology.
2. To stimulate the preparation of articles and papers on topics of interest to its membership.
3. To encourage teachers of graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses.
4. To encourage research, development, and refinement of theory and application of engineering graphics for understanding and practice.

DEADLINES

The following are deadlines for submission of articles, announcements, and advertising: FALL-September 15; WINTER-December 1; SPRING-February 1.

STYLE GUIDE FOR JOURNAL AUTHORS

1. All copy is to be typed, double spaced, on one side only using white paper with black ribbon in standard English. Dot matrix copy is acceptable if high quality.
2. All pages of the manuscript are to be numbered consecutively.
3. SIX copies of each manuscript are required.
4. Refer to all graphics, diagrams, photographs, or illustrations in your text as Figure 1, Table 1, etc. Be sure to identify all material. Illustrations cannot be redrawn. Accordingly, be sure that all linework is black and sharply drawn and that text is large enough to be legible when reduced to 4.25" in width. Good quality photocopies of sharply drawn illustrations are acceptable.
5. Submit a recent, glossy black and white photograph (head to chest). Make sure that your name and address is on the back. Photographs, illustrations or other submitted materials cannot be returned without postage prepaid.
6. The editorial staff will edit manuscripts for publication after return from the board of review. Galley proofs cannot be returned for author approval. Authors are encouraged to seek editorial comment from their colleagues before submission.
7. Enclose all material, unfolded, in a large envelope. Use heavy cardboard to prevent bending.

Continued inside back cover.

THE ENGINEERING DESIGN GRAPHICS Journal

Volume 52 Number 2

ENGINEERING DESIGN GRAPHICS DIVISION

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

DEPARTMENTS

FEATURES

It was in the Fall of 1982 that the package from Mary Jasper arrived and I knew that my life would never be the same. Now, as you read this, a box is winging its way eastward to Blacksburg, Virginia and Barry Crittenden, your new editor. The six years that have passed between these two events have seen eighteen Journals pass across first my drawing board and then my computer; eighteen Journals and eighteen Editor's pages, six Division Chairmen, one publisher, and two universities. It was a big job, probably with the most visibility in the EDGD. Lessons were learned, and from the vantage of the editorship, both great change and no change at all occurred. This last message reviews some of these observations.

Jon M. Duff is Professor of Technical Graphics at Purdue University

FROM THE DESK OF THE EDITOR

Amazing how resilient is the EDGD! It can survive good, bad, or non-existent leadership. It can survive the deaths of major movers and shakers, prestige departments, and most of the teaching topics held near and dear. It can even survive editors who change, or don't change. And just when the future might seem most dim, a new crop of graphics-types appear to take our discipline into new and exciting areas. The last several EDGD Midyear Meetings and ASEE Nationals have seen new and energetic faces. But still, all is not rosey in graphics land. There is still much to be done.

"We thought that our students deserved no less than an industrial strength experience..."

Six years ago, the move to computerize engineering graphics classes was well underway. There was lots of programming going on, a little graphics on non-graphics monitors, and very little computer drawing. The people teaching design were trying to figure out how they could continue to teach the same engineering design problems but either deliver the instruction by computer, or, program the solutions so that diagramatic pictures were the result. A debate centered on what method was best for teaching graphics concepts—the computer or the drawing board. That debate still rages today. Most people were enamored by the computer technology and not by the fundamental change in how engineers interacted with their world. The same professors who enjoyed constructing their own custom slide rules enjoyed writing graphics application programs and our field of study, rather than making a sharp turn in direction, continued on a parallel course, moved only higher on the technological ladder. Thankfully, we see fewer and fewer papers and presentations centered on writing yet another program to

Continued on Page 6

division

EDGD Election Results

Congratulations to the new officers in the Engineering Design Graphics Division.

• Vice Chairman •

Frank Croft

The Ohio State University

• Secretary-Treasurer •

Linda Bode

University of Toledo

• Director of Publications •

Barry Crittenden

Virginia Polytechnic Institute and State University

Retirements

A number of ASEE-EDGD members have recently retired. Among them are Robert (Lash) Larue from Ohio State University and Ken Botkin from Purdue University. Both have served the EDGD and their universities in many capacities. We hope that they stay active in the Division and in ASEE.

jobs

The Ohio State University

The Department of Engineering Graphics in the College of Engineering seeks faculty at all ranks with positions effective October 1, 1988. Responsible for teaching and managing graphics courses along with developing new coursework; serving on departmental, college, or university committees; offering services to the fields of engineering and technology. Minimum qualifications: P.h.D.,undergraduate degree in engineering, and national recognition in engineering graphics for appointment at Full or Associate Professor; MS in engineering or related area for appointment at Assistant Professor. Candidates should have experience teaching engineering graphics, including computer graphics, a publishing record in refereed journals writing proposals and securing funding for development projects.

Contact:

Professor F.D. Meyers
Department of Engineering Graphics,The Ohio State University, 2070 Neil Avenue, Columbus, OH 43210-1275.

Florence-Darlington Technical College

Responsibilities include teaching, drafting (Manual and CAD), statics, strength of materials, mechanisms, materials and processes, and design courses, curriculum, and instructional development; advising and tutoring students. Salary commensurate with experience. B.S., M.S. preferred in engineering, engineering technology, or related field; three to five years in education and/or industry; previous work involving manual and CAD drafting required. Requires excellent communication skills. Contact college for application forms.

Florence-Darlington Technical College
Post Office Drawer F-8000
Highway 52
Florence, SC 29501.

University of Wisconsin-Milwaukee

Industrial and systems engineering, to engage in teaching, research, and development of instructional programs in engineering design and graphics. Doctorate in engineering preferred though master's and experience will be considered.

Contact:

U. Saxena, Chair, Industrial and Systems Engineering,
PO Box 784,
University of Wisconsin-Milwaukee,
Milwaukee, WI 53210.

Editor from page 4

draw this or that.

Setting up laboratories took much of our attention from 1982-1988. We memorized interface designations and disk drive performance data. We all learned FORTRAN and BASIC, and then PASCAL, and C, and so FORTH...We went from Wordstar to Word Perfect to Peachtext looking for the perfect word processor. We memorized hundreds of function key combinations for programs we used for a few weeks. We thought that our students deserved no less than an industrial strength experience so we installed CADAM, Intergraph, McAuto, Autotrol, and Computervision, seeking that perfect graphical high. The microcomputer came out of the toy closet so we tried CADVANCE, CADPLAN, CADAPPLE, AutoCAD, CADKEY, and VERSACAD, looking for that magic package that would somehow do it all. But through it all, only a few cared to address *what* we should be teaching, and to whom. To those few, my thanks. We established the dangerous practice of solving a curricular problem by dumping equipment on it, a practice that unfortunately continues today.

There were debates as to the relationship of engineering, engineering drawing, the design process. I still can't explain it to my dentist's satisfaction. He thinks that if you make engineering drawings you're an engineer. All of my engineer friends seem to know the difference—all PEs and have never made a drawing in their lives. Industrial designers design, but do they engineer, and if they do, are they then industrial engineers?

We had our evangelists for a return to graphics fundamentals, metric conversion, and the teaching of ANSI Y14.X. And we had computer software engineers with brains stuffed with marshmallows writing CAD programs unaware of any of this. We saw *Personal Computer* turn into PC, and PC turn into MS-DOS. Some rushed to embrace Big Blue while others took a particular liking to Apples and all the while what was probably the most capable graphics platform cried for a company that really cared. I have thought a lot about this lately, on the eve (almost any day now) of OS2 and Presentation Manager. There was a reason that the lines were so sharply drawn, between MS-DOS and those (like myself) who started there and realized early that there was no future there. It wasn't that the IBM was inferior technologically. It was that the IBM was wrong. Dead wrong. The fundamental manner in which a human interacted with the machine was based on a faulty conception. What will forever amaze me is that IBM got away with it for so long and made so much money at it. Mark my words, in five years IBM will have us all thinking that *they* were the ones that championed the direct manipulation interface.

"It wasn't that the IBM was inferior technologically. It was that the IBM was wrong. Dead wrong."

What has been the best about these six years? Probably the people. And the places. The memory of campuses and convention halls, of hospitality rooms and banquets. Of places with strange names and strange foods—forming the punctuation for each issue, each year. Memories of late nights in airports followed by early morning classes, returning tired but pumped up. Educators with common problems and common dreams, sharing the same resources that formed common fears. Readers mad at you, readers pleased with you. It probably *was* the people.

national

Short Course at Illinois

Michael H. Pleck, Director of the General Engineering Micro CADD Laboratory at the University of Illinois at Champaign-Urbana is hosting a short course, "Computer-Aided Design Drafting Instructional Approaches. The focus of the short course sponsored by NSF will be on the application of micro-CADD to engineering graphics instruction. The aim of the short course is to enable experienced faculty members to enrich their teaching capabilities and explore new teaching strategies for engineering design graphics courses.

Continued on Page 17

CIEC in New Orleans

The 1988 College Industry Education Conference will be held January 29-February 3, 1989 in New Orleans. Though EDGD does not sponsor a specific session, the Engineering Technology Division (ETD) has several activities planned. These include a technical paper session on Wednesday February 1 at 11:00 am.

An "all division" joint session will address TAC/ABET accreditation changes, general applications of computers in engineering technology, and graduate programs in engineering technology.

review

The Technical Writer
by Ann Stewart
Holt Rinehart and Winston, 1988
339 pp, soft bound

This text represents a transition between manual document preparation and what is becoming to be known as electronic publishing. Yet, it is much more a writing book rather than a computer book. It stresses that it is the process which is important, rather than the tools. Organized into five major parts, the author leads the reader through the process of preparing to write, gathering information, rewriting, editing, and illustrations. It is especially rewarding to see an author stress the rewriting cycle as has Stewart. There is a good treatment of proofreading and proofreader's marks, important to any rewriting or editing activity. The treatment of illustrations is essentially that of charts and graphs though halftone and digitized imagery is briefly touched opon. Computer Assisted Drawing, what the author refers to as CAD, is presented albeit on a superficial level.

The bulk of the text addresses the actual craft of technical writing. Letters, resumes, proposals and feasibility studies, final reports, working reports, and the writing of user documentation are all topics covered in *The Technical Writer*.

The final section covers oral presentations, something that at first glance might seem out of place in a writing text, but on second glance is right on target. Technical documentation quite often accompanies an oral report. It may be the oral report that gets the project approved with the actual written report serving as background information. This section also touches on the need for visuals to accompany the oral report. However, there is no bibliography, a needed addition seeing that several topics, the graphics in particular, are not covered in sufficient depth for this text to stand alone.

The Technical Writer is good reading for all technical educators with many examples of technical documents applicable for professorial and consulting writing. -ed

Comment

Author Suggests Further Evidence for Ellipse in Perspective

Charles G. Moore
Northern Arizona University

The spring 1985 issue of Engineering Design Graphics Journal carried an article by me entitled "Putting the Ellipse in Perspective." In that paper I presented the analytic geometry that can be used to identify the center, angle of rotation and major and minor axes of the ellipse which represents the perspective view of a given ellipse inscribed in a rectangle.

The exposition and my mathematics were, however, based upon the assumption that the perspective view of an ellipse is itself an ellipse. Subsequent letters to the editor showed that not all readers accepted this assumption. Indeed, it is not intuitively evident. A casual consideration will lead one to conclude that the perspective view of an ellipse is a somewhat egg-shaped distortion of the ellipse being viewed.

My discussion will be based upon Pascal's Theorem which is proved in any standard text on College Geometry. Pascal's Theorem states: "If a hexagram be inscribed in any conic, then the points of intersection of pairs of opposite sides are collinear, *and conversely*" (italics mine). The particular conic with which we are concerned is the ellipse. If six points located on an element of the ellipse are joined in sequential order, the resulting convex figure is referred to as a hexagon. However, Pascal's Theorem applies if six points on a side are joined in any order. The six-sided figure with sides intersecting within the ellipse is called a hexagram.

"It is fascinating that an ellipse cotinually presents new ellipses to the eye regardless of the angle or distance from which it is viewed."

The converse of Pascal's Theorem states, "If, for any hexagram inscribed in a curve the intersections of opposite pairs of sides are collinear, then that curve is a conic." Consider Figure 1.

In the figure a given ellipse in a horizontal plane, S, is viewed by an eye at point E. Rays are projected from all points of the ellipse of E. A plane, P, orthogonal to the line of sight intersects the family of rays from E to the ellipse. The plane, P, is the *picture plane* and the projection of the ellipse onto P is that which the eye sees when viewing the ellipse. The question to be answered is, "Is the projection of the ellipse onto the picture plane, P, an ellipse?"

A plane π situated obliquely with respect to the line of sight also intersects the family of rays from the ellipse in S to E such that the intersection is a closed curve. A hexagram (not necessarily convex) is inscribed in the given ellipses and the intersections of opposite pairs of sides identified. Pascal's Theorem states that these three points are collinear and the "Pascal Line" through them is shown as a bold line in the plane S. Now consider the projection of the entire figure in plane S onto the oblique plane π. Since collinearity is preserved under a central projection, the Pascal Line in S is projected into a straight line in π. This would be true regardless of which six points on the original ellipse in S were chosen to form the inscribed hexagram.

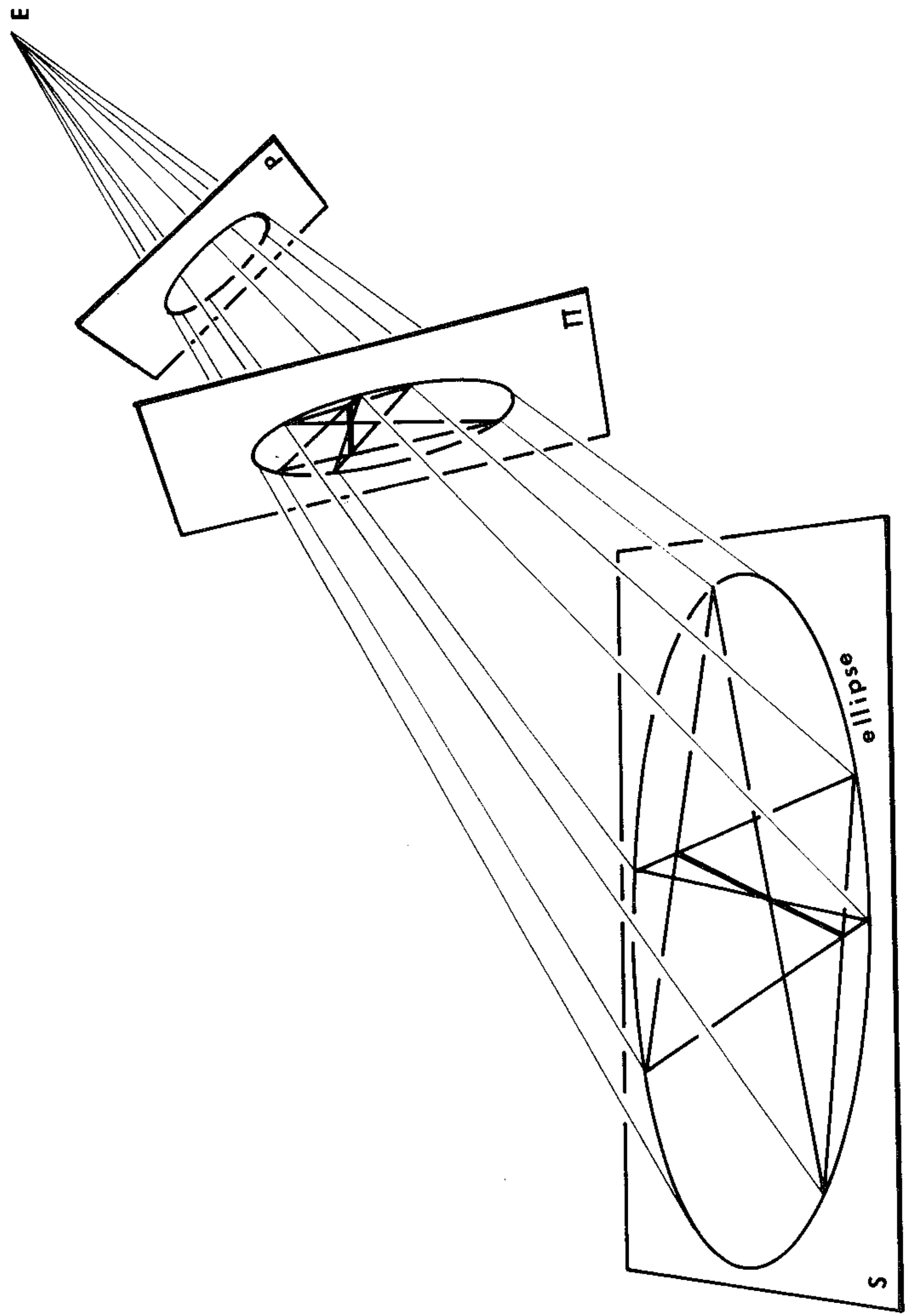


Figure 1

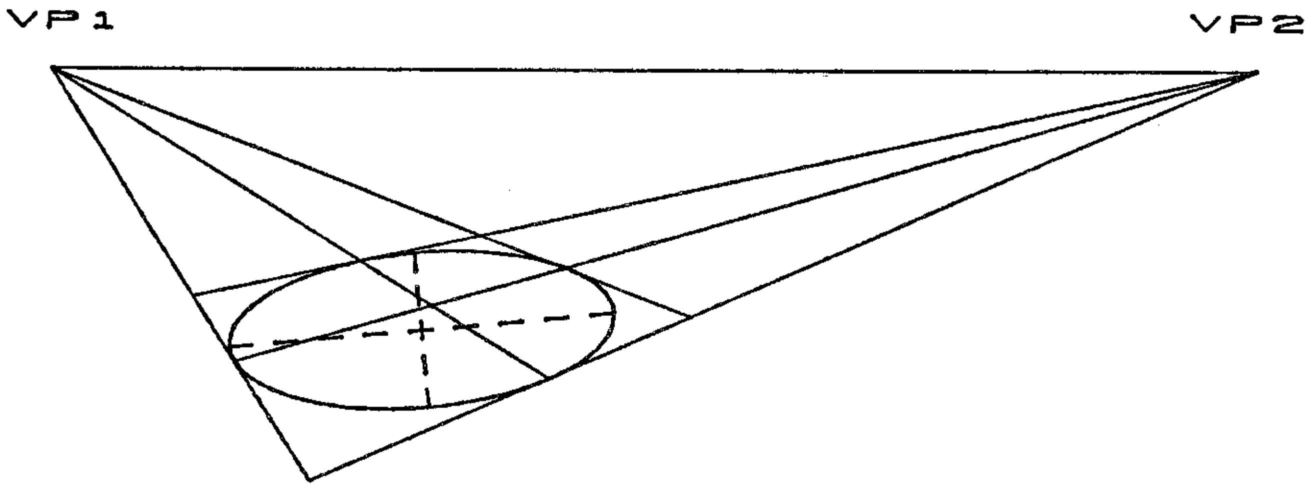


Figure 2a

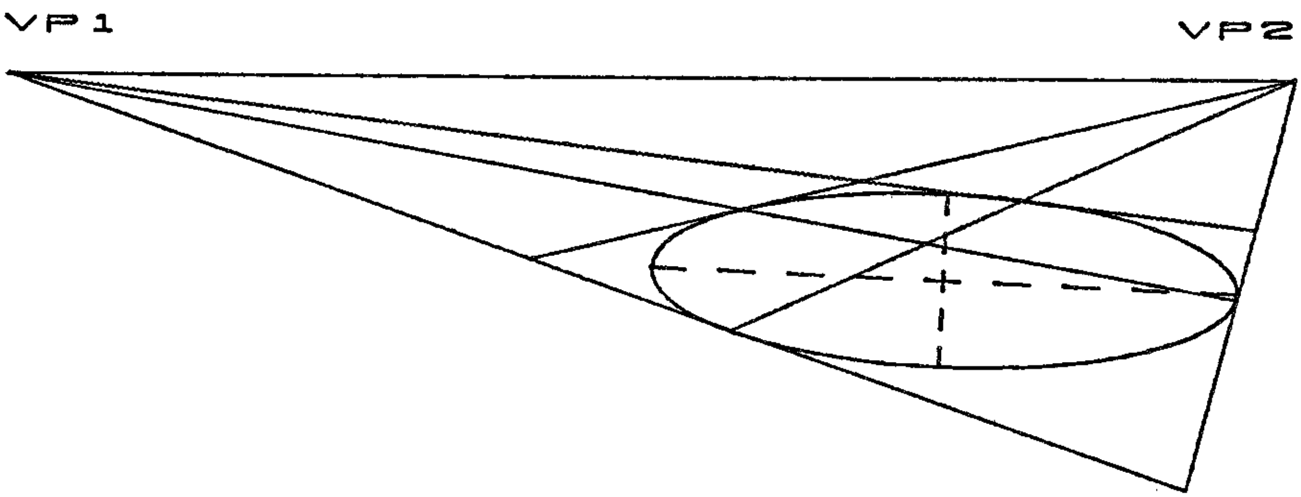


Figure 2b

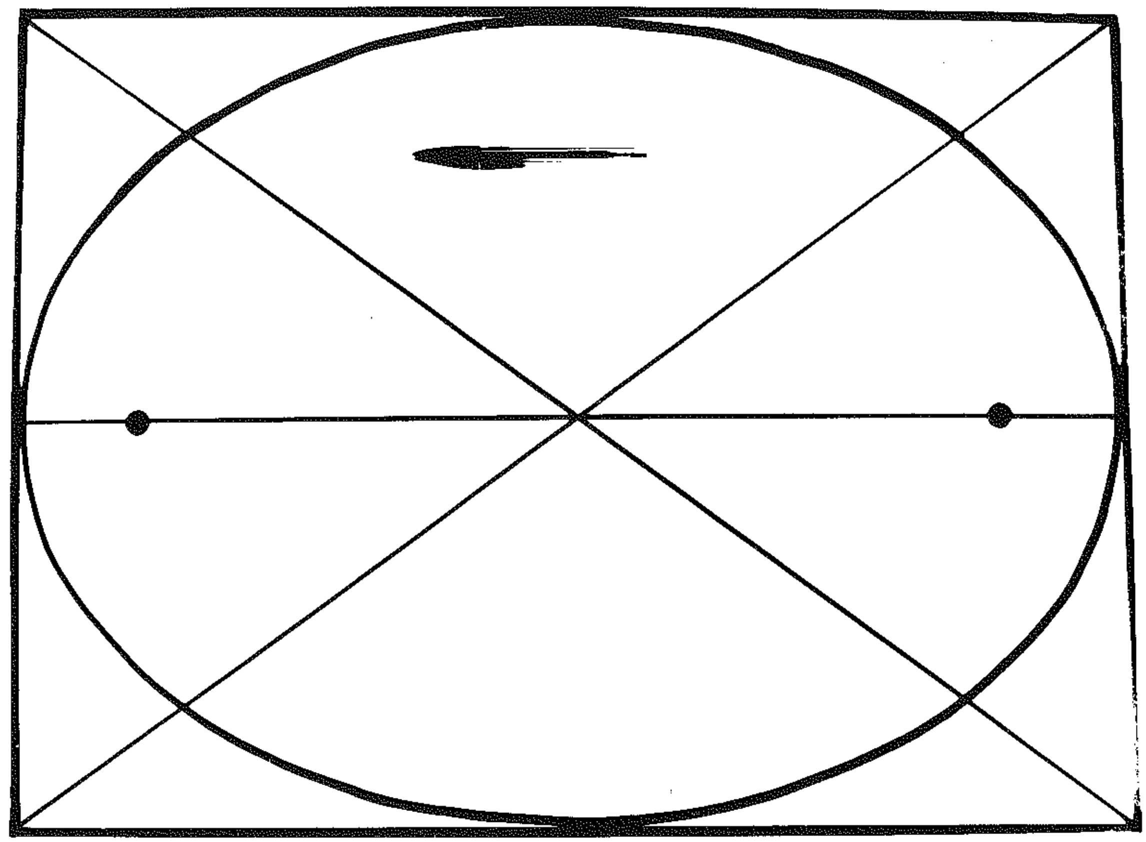


Figure 3

The converse of Pascal's Theorem asserts that the figure projected onto the plane π is a conic. Further, the ellipse in S projects into a closed curve in π and the only closed conic is an ellipse.

Thus the projection of an ellipse in S onto *any* is an ellipse and consequently the projection of the ellipse S onto the picture plane P is an ellipse and the questions addressed by the paper is answered in the affirmative. A mathematics student, Darrell Denlinger, accepted the challenge of writing a program with graphics employing the mathematics of the spring 1985 issue of EDGJ. Examples of those printouts with the ellipse in perspective are shown in Figures 2a and 2b.

A copy of Denlinger's program will be supplied on request.

For visual confirmation the expertise of a technical photographer from the Bilby Research Center was enlisted to photograph at various extreme angles an inscribed ellipse with diagonals and foci drawn to determine if the photographic image itself revealed an ellipse. The original ellipse had major and minor axes of approximately 55 cm. and 35 cm. respectively. A Swiss army knife is shown for scale. See Figure 3.

Two of the photographs are shown as Figures 4a and 4b, and it was easily confirmed by comparison with professionally prepared templates that the photographic images were indeed ellipses. See Figures 4a and 4b.

It is fascinating that an ellipse continually presents new ellipses to the eye regardless of the angle or distance from which it is viewed.

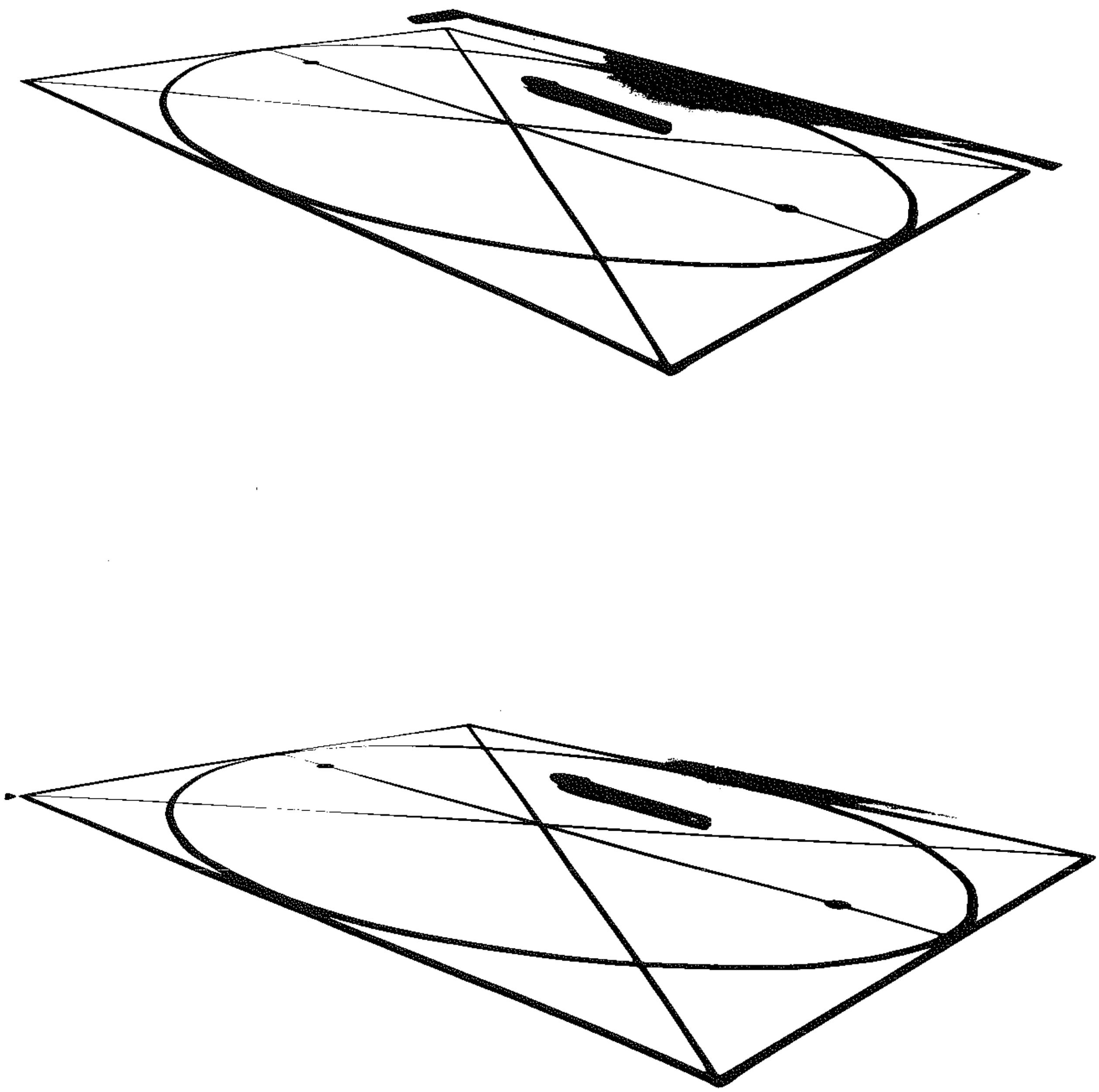


Figure 4a&b

Figure 5

In the previous article I described a device I call an ellipsicom (ellipse compass) with which one can draw a continuous ellipse of any given major and minor axes. An improved version of the ellipsicom is shown in Figure 5.

The Systems Side of Computer Aided Design: Computers, Software, Laboratories

Dennis R. Short,
MSed, CMfgE
Purdue University,
W. Lafayette, Indiana

Introduction

Computer Aided Design (CAD) is a machine dependent technology. The implementation of Computer Aided Design courses requires the acquisition, operation and maintenance of one or more computer systems. These computer systems may range in complexity from low-end micro-computers to high-end distributive mainframe systems. The decision of which type of system to use and how to facilitate laboratory implementation and operation are decisions whose effects will remain for years to come.

Computer Aided Design laboratories are expensive, complex, and have life spans averaging four to five years maximum. The initial cost of the laboratory is often outweighed by the costs of operation and maintenance. The actual design and structure of the laboratory may also limit or restrict the pedagogical choices the institution may have available when selecting how CAD instruction is to be delivered. CAD laboratories may be multi-functional facilities which also support general computing instruction or a laboratory may be closely tied to a research effort. The laboratory's capabilities will usually include the capacity to support related areas such as Computer Aided Engineering (CAE) or Computer Aided Manufacturing (CAM).

Failure to carefully evaluate the actual requirements of the laboratory or to consider the full impact of system selection and actual laboratory layout may result in early obsolescence or abandonment of the facility. Potential problems can be avoided by a careful, detailed specification of the laboratory requirements, and by using potential vendors as a source of technical information. Human resources, such as systems management and service capabilities, should not be overlooked in the acquisition and operation of the CAD facilities. The cost and visibility of Computer Aided Design laboratories make mistakes diffucult to hide and even harder to live with.

> "The reputation of the vendor and the ability to establish a working rapport are extremely important."

Form and Function

The questions that should be asked when beginning to specify a Computer Aided Design laboratory can be broken down into five basic areas:

1. What is to be taught in the laboratory and at what level are these subjects going to be taught?

2. How many students will be taught at each level and what is the anticipated enrollment and rate of growth for each area?

3. How will the laboratories be organized? Will the laboratories be structured or open?

4. How does this new laboratory "fit in" with other courses and laboratories?

5. What administration attitudes or preference will affect the facility and the equipment selection process?

These general questions can be used to establish a set of boundaries within which group responsible for the development of the CAD laboratory can work. The responses to these questions should represent a working document that has been approved by higher administrative and fiscal authorities.

The First Steps

Following the establishment of the boundary conditions for the laboratory, a set of software specifications should be developed. This set of specifications is linked to what will be taught in the laboratory, at what level the material will be taught, and how the laboratory will integrate into the overall system. Software selection will be used to determine hardware requirements.

Software selection is dependent on how CAD will be taught. Will it be taught as Computer Assisted Drafting or as true Computer Aided Design? Will the data base created under CAD be required to integrate into Computer Aided Engineering or Computer Aided Manufacturing environments? If so, what are the software requirements at these levels? Will the modeling be wire-framed based, surfaces, or will Constructive Solid Geometry (CSG) be used. The questions that should be asked indicate an important point. The requirements of the laboratory cannot be specified without a knowledge of the entire field of Computer Aided Design and its related disciplines.

The heart of any Computer Aided Design system is the software. Software now accounts for an average 70 to 80% of total system cost for non-educational environments. The ability to migrate data across software and system boundaries is an important consideration. The "soundness" of the software and the availability of adequate support documentation, application support, and the rapid correction of software "bugs" are as important as any other factors that may be considered. The reputation of the vendor and the ability to establish a working rapport are extremely important.

Laboratory Structure

How classes are structured will have an important affect on all other design aspects of the laboratory. If the laboratory experience is structured around a module of activities that the student is expected to complete within the given laboratory period certain restrictions come into play. This type of structure puts a limit on the number of students that may be taught.

If a laboratory has 8 workstations available and the school has 8 hours of instruction per day, 160 students could be supported in two-hour laboratory periods. All systems work and developmental or research activities must be performed outside these hours. Further scheduling problems occur if an individual work-station is inoperative or if the semester schedule results in an odd number of a particular day of the week. Further difficulties can occur if the exercises are highly structured and the laboratory utilizes a single resource such a central computer or network server. An instruction such as "Now everyone hit return." can result in impulse loading of the system and make the entire laboratory unusable for a short period of time.

An open laboratory structure is organized around the concept that students are sufficiently responsible to manage their own time and that each student completes assigned exercises prior to a deadline. The restrictions associated with this approach include the need to provide consultants or assistants to monitor the laboratory and to answer questions and the impulse loading the system may experience if all 160 students attempt to complete an exercise the evening before it is due. The advantages of the open laboratory concept include the ability to operate the laboratory extended hours and allowing for considerations of differences in students' learning speeds. The open laboratory also permits free time to experiment with the system outside a highly structured or restrictive environment.

The best solution appears to be the use of structured laboratories in introductory courses and the use of open laboratories for advanced classes. This arrangement permits the presence of the instructor in the laboratory to provide reinforcement and encouragement as students learn to use a complex system and maximizes the system's utilization by operating the system evening and weekends. It is important that the initial experience of a student using a complex system or device be positive and produce tangible results.

Prevailing Trends

From a technical point of view, the field of Computer Aided Design is beginning to settle down and shakeout. The predominant vendors in the area have been rather stable for a couple of years now. IBM and DEC lead the field by virtue of their lead in general computing. Intergraph, Computervision and Applicon follow in a group representing turn-key vendors. This market stability has been achieved by a number of events:

1. the slowed pace of the adoption of new computer technology

2. the development of system conformity and standards,

3. the emergence of user loyalty,

4. standardization of systems by some large users,

5. the shakeout of micro-CAD vendors leaving a number of clear leaders.

These events, combined with the emergence of UNIX™ as an operating systems standard and C as a standard programming language have greatly simplified the task of specifying a CAD system which is not micro-computer based. Systems not based on micro-computers can be placed into three distinct categories:

1. mainframe based systems,

2. super-Mini based systems,

3. workstations (32 bit) based systems.

While other systems exist, these are the primary categories. The newest of these categories, 32-bit workstations, is a significant development.

Workstations represent the availability of stand-alone dedicated mainframe capability for each user. Combined with standard networks, such as TC/IP Ethernet local area networks, they provide what the author considers the ideal computational environment. Speed improvements of five-to-ten fold over super-mini based systems combined with decreased per station costs, no special environmental requirements, and the ability to add additional capacity incrementally, are major advantages. All current major vendors of commercial CAD software are migrating their systems to the Unix™ based workstation environment. That is, all except for one notable exception, IBM.

Along with the emergence of workstations as a major force in the CAD hardware arena, software has also changed. CAD software is no longer tied to a particular piece of hardware. CAD software packages from a single vendor may now be available to run on several different vendors' hardware and operating systems. This trend is further enhanced by the introduction of packages by third-party vendors which permit the direct translation of data from one system's data base to the form required by a different vendor's data base. A very important process is occurring: convergence.

The Micro Computer Arena

The micro computer arena is divided between two players on the hardware side and possible six major players on the software side. The major software players, IBM and Apple, have both recently introduced major changes in their respective line of systems, disrupting what had been a refreshingly calm environment. What had been an easy solution, selecting the IBM PC/AT from which to build a micro-CAD based laboratory, is now a clouded and confused environment. The Apple Mac II is at the leading edge technically and IBM's System/2 offers less than was hoped for by many IBM users. Both new hardware systems reflect a tendency for high-end micro-computers to present the capabilities of a workstation. But this may be less important than the development of packages, such as VersaCAD™, which will now run on both systems.

Until recently, microcomputer based CAD required expensive software and/or hardware to operate. Low cost CAD packages under $1,000 are now available while packages like the Personal Designer System provide multi-view true 3-D modeling with surfaces and shading capabilities.

The questions all of these developments raise include: What is the best mix of systems? How are CAD resources best organized to deliver the optimum cost of instructional delivery? The cost per station of a CAD laboratory can range from $4,000 to $80,000 depending on final configuration.

Optimization

A number of vendors offer software platforms at all hardware levels. The data bases produced by these systems are both upward and downward compatible. IBM offers versions of CADDAM™ which can be run on systems ranging from the IBM PC/AT's and RT workstations to mainframes and super-mini computer system. Computervision offers a series of compatible software products that run on the IBM PC/AT, Sun Unix™ based workstation, and their proprietary CDS 4000 system of hardware. The trend in industry is away from proprietary hardware systems toward an open architecture and compatible operating system. Again, however, with one notable exception, IBM has moved away from an open architecture toward a closed architecture with the IBM System/2 using the not yet released (as of this writing)OS/2 operating system.

The cost of fully configured personal computers is only marginally less than basic workstations. The cost of software for personal computers is often substantially less than the cost of software for workstations when purchased as individual licenses. Site, or multi-station licenses, are easier to obtain for workstations and may yield substantial savings. Periodically, one of the major software vendors will offer grants of software or discounts which amount to give-aways. These offers may be a useful vehicle for acquiring software for introductory laboratories.

Hidden Costs (and Problems)

Often overlooked are operating and maintenance costs. In the academic environment, the funds may be available for acquiring a laboratory, but often no funds are available for ongoing operation and maintenance. Even a donated system may to expensive to use.

The hidden costs are monitor help for open laboratories, paper costs, magnetic media, and insurance. Documentation can be a major item at $100 or more per manual on some systems. Certain hardware vendors will not even answer questions on how to install and operate a system unless a support contract has been purchased. The cost of incidental hardware, startup supplies, and preventive maintenance must be considered.

A cost often overlooked is the cost of the floor space to support the laboratory. At many universities, there is simply no room for additional laboratories. Access to open laboratories may also cause significant security problems. Make sure you have a place to put your laboratory.

Conclusion

The implementation of Computer Aided Design laboratories requires careful planning and an understanding of how decisions will affect both the operation of the laboratory and pedagogical options available for delivering CAD instruction. The number of options available may not be as numerous as the vendors would have you believe. The major decision is what software to use and how to integrate the CAD laboratory into other facilities and courses. Approached carefully, with no preconceived ideas, the development of CAD laboratories should be achieved with no more problem than any other educational facility.

Illinois from page 7

An interesting aspect of this short course is that there are no fees for the course or for materials. Meals will be provided along with hotel accommodations and a stipend of $250.00 will be provided to each successful participant. Participants, or their home institutions, are expected to bear travel costs. The Journal expects to report on Illinois' experience in this area.

The Role of Computers in the Design Process

Presented at the 1987 EDGD Mid Year Conference

Gary R. Bertoline
Department of Engineering Graphics
The Ohio State University
Columbus, Ohio

INTRODUCTION

In most engineering and technology programs, engineering graphics is a basic component of the curriculum. Representing the world graphically is a fundamental communications skill used by designers, engineers, and drafters to change their conceptual design into sketches or engineering drawings. Traditional methods of creating graphics in industry and education have been through drawing instruments such as the t-square, compass, triangle, and pencil (figure 1). Recently, the computer has been found to be a more efficient and effective tool for many tasks when representing designs graphically. This has led to the introduction of CADD (Computer-Aided Design/Drafting) into engineering and technical drawing and other fields that require graphics for communications (figure 2).

CADD is an automated method of generating graphics for designing and drafting through the use of a computer and other peripheral devices. It can be used to supplement or replace traditional drafting and designing tools. In industry, CADD is rapidly supplementing or replacing the traditional tools used to create engineering drawings.

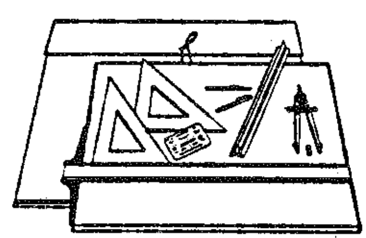


Figure 1

CADD: THE LATEST TOOL USED FOR ENGINEERING GRAPHICS

In the last twenty-five years there has been major growth in computer technology and in the use of computers to create graphics. The growth of computer graphics has closely followed the evolution of the computer. As computer hardware and software technology became more powerful and less expensive, the use of computers to generate graphics became more common in industry. This led to the development of software that could be used for the design process.

THE DESIGN PROCESS

The design process is used to organize the creative and analytical procedures necessary to satisfy a need or solve a problem. Although many models have been used to describe the design process, the model depicted in Figure 3 has the major components traditionally associated with design.

THE DESIGN PROCESS USING TRADITIONAL TOOLS

The traditional tools used in the design process are those normally associated with drafting and model-making. After the problem is identified in *stage 1*, concepts and ideas are collected for *stage 2*. This is usually accomplished by rough sketches using paper, pencil, and eraser. These rough sketches are quickly made so that possible design solutions can be recorded before they are

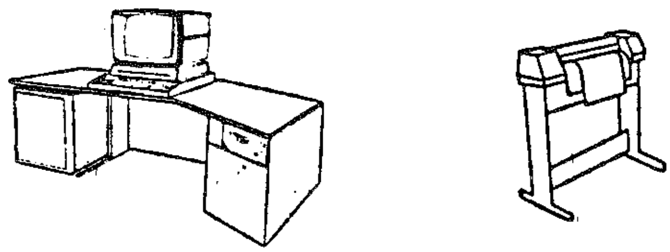


Figure 2

forgotten. From the collection of rough sketches, a compromise solution(s) is selected for *stage 3*. Rough schematic drawings may be produced to test the design. A design layout made with instruments is then produced from which models can be created or further graphical or analytical analyses can be performed.

Stage 3, 4 and *5* are highly interactive and iterative steps. A design solution may be analyzed and found to be needing change. This would cause the designer to go back to *stage 3* to modify the design. This process of design, analysis, and optimization may occur a number of times before the final design is chosen.

After the design has been analyzed it is evaluated in *stage 5* by building models or prototypes. To accomplish this, dimensioned sketches or rough working drawings must be created for the model shop craftperson. The model or prototype is tested and any design modifications are noted on the drawings.

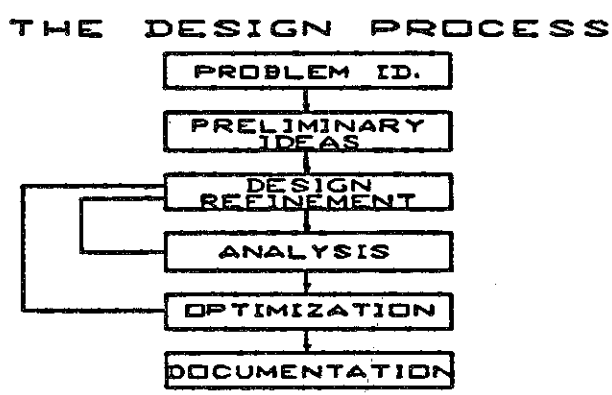


Figure 3

After the final design is approved working drawings are produced for the manufacture of the product. The working drawings created in *stage 6* usually consist of detail drawings of the part(s), a parts list, and an assembly drawing. Traditionally the design process was accomplished on drawing boards. However, with CADD much of the design process can be performed with the computer.

THE DESIGN PROCESS USING CADD

The first change in the design process is the use of the computer as a design tool. Interactive design stations allow designers to explore many more alternatives that have been possible with traditional tools (Whitney, 1985). The use of computers for the design and documentation of a product can be grouped into 4 main areas:

1. Geometric Modeling
2. Engineering Analysis
3. Design Evaluation
4. Documentation

These four areas can be interfaced with the last four stages in the design process as shown in Figure 4 (Bertoline, in press). Powerful CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) systems are capable of replacing traditional tools used for the last 4 stages in the design process.

Microcomputer-based CADD, such as AutoCAD, traditionally has been used for the last stage in the design process— documentation. This is rapidly changing as improved hardware and software are being created. It is now possible with AutoCAD, CADKEY, and VersaCAD, to create a 3D wire-frame model of a part and surface shade the design. Many third party products have been developed that can be used for the design and analysis of a model created on a microcomputer-based CADD system. Drawing files can also be used on powerful CAD/CAM systems through graphic translators.

GEOMETRIC MODELING

Geometric modeling can be used to supplement or replace traditional tools used in *stage 3* of the design process. A geometric model is a mathematical representation of a design created with a CADD system. This mathematical description allows the model to be displayed, manipulated, and edited. There are three primary methods of creating a geometric model of a part with CADD:

1. Wire-frame
2. Surface
3. Solid

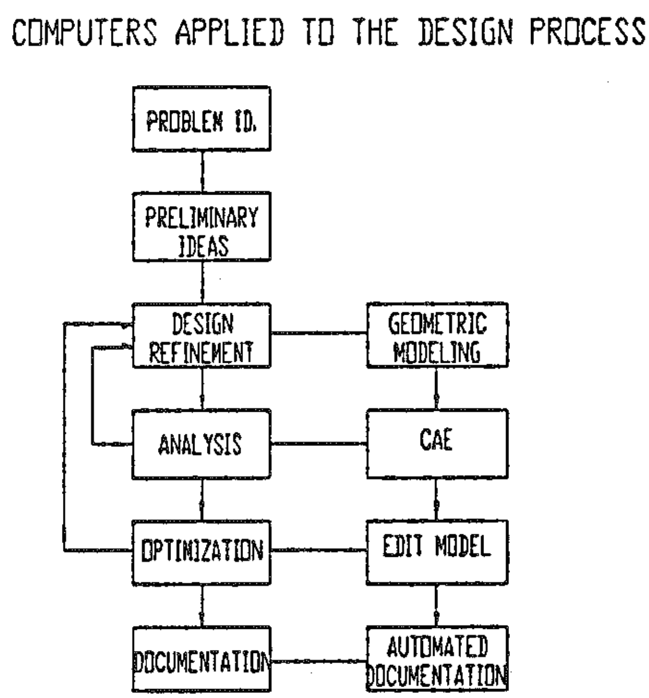


Figure 3

Of these, the solid model provides the most information about a design and therefore is the most useful These mathematical computer models can then be analyzed just as a prototype or model can be studied.

ENGINEERING ANALYSIS

After the geometric model is produced, the computer can be used to analyze the part as shown in *stage 4*. This is accomplished through various computer engineering analysis programs such as

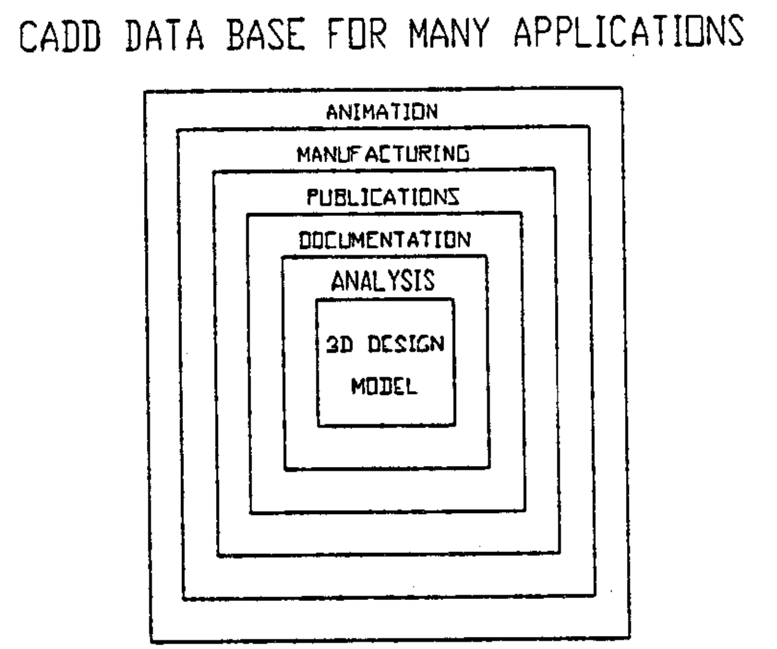


Figure 4

stress, strain, kinematics, and heat transfer. Two important examples of this are the analysis of mass properties and finite element analysis. Mass properties analysis provides information about the surface area, center of gravity, weight, volume, and moment of inertia. Finite element analysis provides information about stress-strain, heat transfer and other characteristics of the model. This information can be in the form of colored images displayed on the CADD screen. The design and analysis of a part can be performed by the same person on the CADD workstation. This results in a time savings and a design which is closer to optimum (Grover & Zimmers, 1984).

DESIGN EVALUATION

Parts can be checked for accuracy with a CADD system through automatic dimensioning. Details can be checked by zooming-in and magnifying small parts and details. Layering can be used to match parts for fit and accuracy. 3D models can also be checked for interference between mating parts or parts that pass close to each other. Motion can also be displayed to reveal design flaws and imperfections. This can be accomplished using kinematics packages that can be used to animate simple design mechanisms.

DOCUMENTATION

CADD can also be used to supplement or replace traditional tools in *stage 6* of the design process. If the CADD system was used for the design of the part, hard-copy engineering drawings can be created directly from the CADD data base. This also eliminates drafting and documentation errors. This is possible because there is no manual handling of information (Grover & Zimmers, 1984). Automated drafting procedures include:

1. Dimensioning
2. Cross-hatching for section drawings
3. Scaling
4. Copies
5. Mirror
6. Enlarged details
7. Rotation
8. Isometric and axonometric views
9. Symbols
10. Editing

The geometric data base created for the design can also be used by graphic artists, technical illustrators, sales, and publications. Figure 5. All these areas can be included in the documentation phase of the design process. Graphic illustrators can use the 3D models for their artwork. Technical illustrators can use the 3D models for exploded assemblies, parts lists, and other illustrations used in manuals. The sales staff can use the models for advertising, and sales brochures. The technical manuals, sales brochures and other documentation containing text can be created on the CADD workstation using desktop publishing software.

> "The advantage of using the computer is in its speed and not in its quality."

CAD/CAM

It is now possible with CADD to supplement or replace the traditional tools used in the last 4 stages of the design process. In addition, once the graphic data base for the part has been created it is possible to develop the manufacturing data base that can be used for CAM (Computer-Aided Manufacturing). Traditionally, design and manufacturing was a two-stage process. The engineering drawings were produced by the design drafters then used by manufacturing engineers to produce the product. An integrated CAD/CAM system can provide a direct link between these two processes. CAD/CAM can automate the design and manufacture of a product then automate the link between these two processes. As an example, the CADD data base can be used to automate the following manufacturing processes:

1. Tool and fixture design.
2. Numerical machine control programming.
3. Computer-aided process planning.
4. Production planning and scheduling.

FUTURE CONSIDERATIONS

To the designer, CADD offers a chance to design in a way that was not possible using traditional tools and mass production. Automation of design and manufacturing allows more specialized designs that do not need to be mass produced to be profitable. The early stage of the design process, problem identification and concepts and ideas, are not well supported by current computer technology. The early stage of thc design process is a very creative process that needs simple tools that can quickly record a designer's thoughts. Unfortunately, CADD systems, in spite of vendors' opinions, are not user friendly. The human interface must be improved before CADD can be used in the early stages of the design process. What is needed is an effective way to gather and organize information in a manner that leads to more intelligent solutions to problems (Whitney, 1985).

Computers can be used in problem identification by allowing one to list the attributes of the various parts of a problem and restructure them so that new insights can be gained. Gathering information important to a design can be aided by the computer through data base searches. This information can then be organized into a structure that relates to the problem.

Newer systems will attempt to provide assistance to designers through pictorial displays that will enable designers to keep up with their thoughts (Hooper, 1985).

Continued on Page 30

Computer Graphics at the Senior/Graduate Level

Vera B. Anand
Clemson University

INTRODUCTION

All engineering disciplines have undergone curriculum changes in recent years, especially relating to the incorporation of the new and volatile area of CAD/CAM. Computer graphics has emerged in this context as a field with a strong base of scientific knowledge and of great use in any engineering application related to design and manufacturing. For this reason, engineering schools throughout the U.S. have introduced computer graphics courses in their curricula as an interesting and useful alternative for a technical elective at the senior-undergraduate or graduate levels.

This paper describes possible content and applications of such courses and reviews the rationale for their implementation in the different engineering curricula.

RATIONALE FOR IMPLEMENTATION

Curriculum changes must occur in all disciplines to account for the continuous accumulation of new basic knowledge. The introduction of computer applications at all levels of instruction has been responsible for many of these changes. The body of knowledge commonly referred to as "computer graphics" has progressed visibly during the last few years and should be a part of the engineering curriculum. Several recent publications have addressed the present and future role of graphics in education and industry (1,2,3), emphasizing the need to make engineering students literate in this area.

Many universities, recognizing the importance of computer graphics, have introduced it in their curricula as an appropriate elective for all engineering disciplines. The second SIGGRAPH directory of college-level computer graphics education (4) lists several of these courses by name and level of instruction. Topics typically covered address three basic areas:

"All students in this course are required to complete several exercises involving both graphics programming and the use of interactive software."

- ✔ Input/output hardware and graphic displays
- ✔ Interactive graphics software
- ✔ Mathematics and algorithms for graphical display.

Variations of this course format are presently being studied, allowing for a more comprehensive introduction of computer graphics to engineering students. The education committee of SIGGRAPH has proposed that the course content described above be split into two courses, one part of the core curriculum and the other an elective (5). The core course would cover topics relating to interactive systems design, including basic graphics and human factors. The elective course would focus more closely on the algorithms and mathematics necessary for generating graphical images. Although this alternative seems excellent, the cost of implementing an additional course in any curriculum may be too high. Limitation in faculty resources and number of credit hours to be taken by the students severely hamper the usefulness of this suggestion.

COURSE DESCRIPTION

At Clemson University a computer graphics course such as that above has been implemented and is offered as a technical elective to senior-undergraduate and graduate students in the College of Engineering. It focuses closely on advanced algorithms for generating graphical displays and on the rich mathematical background from which they are built. A special emphasis is given to the application of computer graphics in the solution of engineering problems, particularly with respect to computer-aided design. The course also introduces the students to the general area of geometric modeling.

The topical outline includes:

- ✔ Introduction to computer graphics and graphics hardware
- ✔ 2D transformations and techniques
- ✔ 3D transformations
- ✔ 3D viewing operations
- ✔ Data representation and object description
- ✔ Mathematics for the representation of curves and surfaces
- ✔ Visual realism in 3D graphics
- ✔ Applications to Computer-Aided Design.

The course is divided into lecture and laboratory components, allowing for the study of theoretical concepts and implementation of these concepts into actual graphics systems. The hardware facilities available at Clemson University in support of this course are as follows:

- VAX 8650 mini-computer
- 16 Tektronix 4107-CX graphic displays
- 16 Tektronix graphics tablets
- 2 Tektronix ink-jet printers
- 2 Versatec plotters

Two software packages are used by the students: Precision Visual's DI-3000, and PDA's PATRAN Plus. The first one, DI-3000, consists of a series of FORTRAN-callable subroutines and requires the development of an appropriate code for each individual application. Its use gives the students a first-hand understanding of how the theoretical concepts learned in class can be implemented in a general graphics application. It also allows the students to link the graphic subroutines to any FORTRAN code they develop, thus enhancing their understanding of the engineering problem being solved. This programming component of the course has proved to be of great benefit as an instructional tool.

PATRAN Plus, on the other hand, is interactive solid modeling software requiring no programming, and can be used as a pre- and post-processor. At Clemson University it is linked to both an analysis package for calculations and a 2D drafting package for documentation. To facilitate the introduction of this solid modeler in a classroom environment, an instructional facility was developed locally for student use. It allows PATRAN to be called from a FORTRAN program and guides the student through the several command structures of the software. Figure 1 shows the composition of this instructional program, which consists of several menus and contains an extensive help facility. The linkage with PATRAN is done through a LIB$SPAWN routine available in the operating system of the VAX host. The flow-charts in Figure 2 represent the process of communication between PATRAN and this FORTRAN program. This instructional facility has become an excellent learning tool for the first-time user of PATRAN, and is a very efficient way of introducing students to the software.

APPLICATIONS

All students in this course are required to complete several exercises involving both graphics programming and the use of interactive software. This assures their understanding and usage of computer graphics techniques in the solution of engineering problems. The required exercises are relatively simple and are drawn from several engineering disciplines, reflecting the varied interests of the students.

Toward the end of the semester the students are required to prepare a final project, which usually includes the application of graphical display techniques to the solution of a problem in their specific engineering discipline. Several samples of these final projects in various disciplines are discussed as follows:

- Figure 3 shows output from a program developed by a mechanical engineering student using DI-3000. It calculates the positions of a kinematic mechanism and displays them in a form that allows the user to step through the mechanism's motions using a single key on the keyboard.

- Figure 4 shows the geometric model of a grip robot in various positions. This model was prepared interactively using the concepts of constructive solid geometry (CSG).

- Figure 5 shows the geometric model of a hip prosthesis. This model was prepared by a student in the bio-engineering department and was later sent to an analysis package for calculation of normal loading stresses on the hip joint.

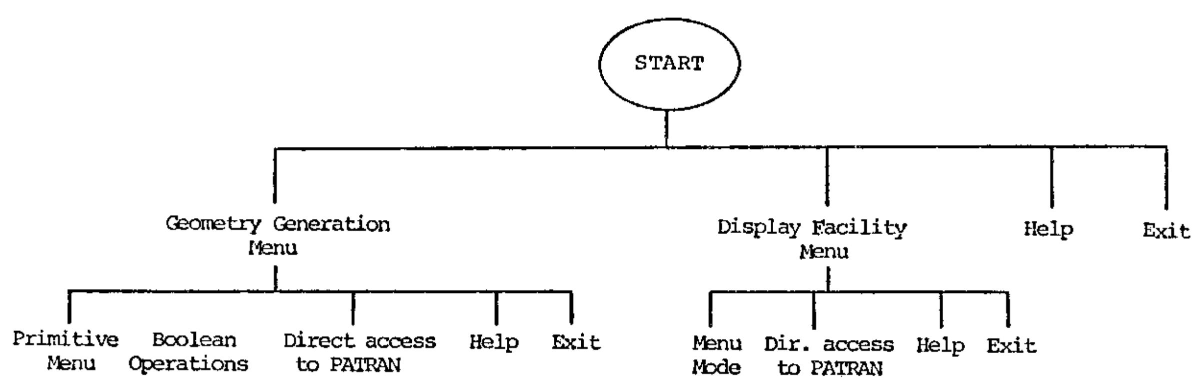


Figure 1

•Figures 6 and 7 show a study of two cardiac valve prostheses done by geometric modeling.

CONCLUSIONS

The importance of introducing a computer graphics course at this level in the engineering curriculum cannot be overemphasized. It not only acquaints students with the basic concepts of interactive computer graphics, but also reinforces mathematical concepts needed in the area of computer-aided design and manufacturing. Furthermore, current emphasis in industry on the recruiting of engineering graduates with a computer graphics background makes it essential to expose all engineering students to this area.

REFERENCES

1. W. Myers, "Computer Graphics: The Next 20 Years." *IEEE Computer Graphics & Applications*, Volume 5, Number 8 (August, 1985).

2. E.T. Boyer and M.M. Khonsari, "Engineering Graphics Today, in 1990, and in the Year 2000." *The Engineering Design Graphics Journal*, Volume 50 No.2.

3. V. Anand, "Survey on the Utilization of Computer Graphics in Engineering Education," *CoED Journal*, Vol. VI, No. 2 (April-June, 1986).

4. S. Cunningham, "Second SIGGRAPH Directory of College-Level Computer Graphics Education." *Computer Graphics*, Volume 19, No. 4 (November, 1985).

5. M. Ohlson, "Computer Graphics Course Recommendations in Computer Science and Engineering Education." *Computer Graphics*, Volume 20, No. 5 (October, 1986).

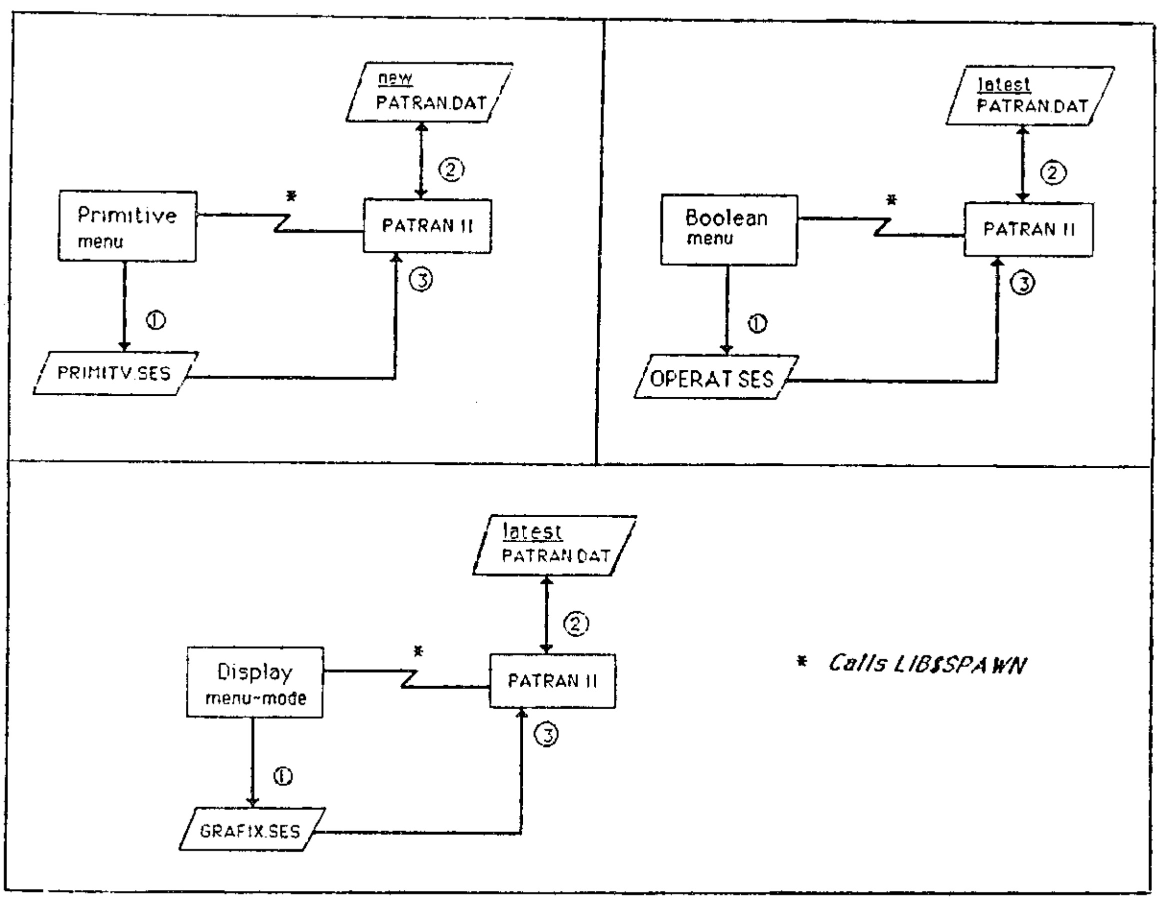


Figure 2

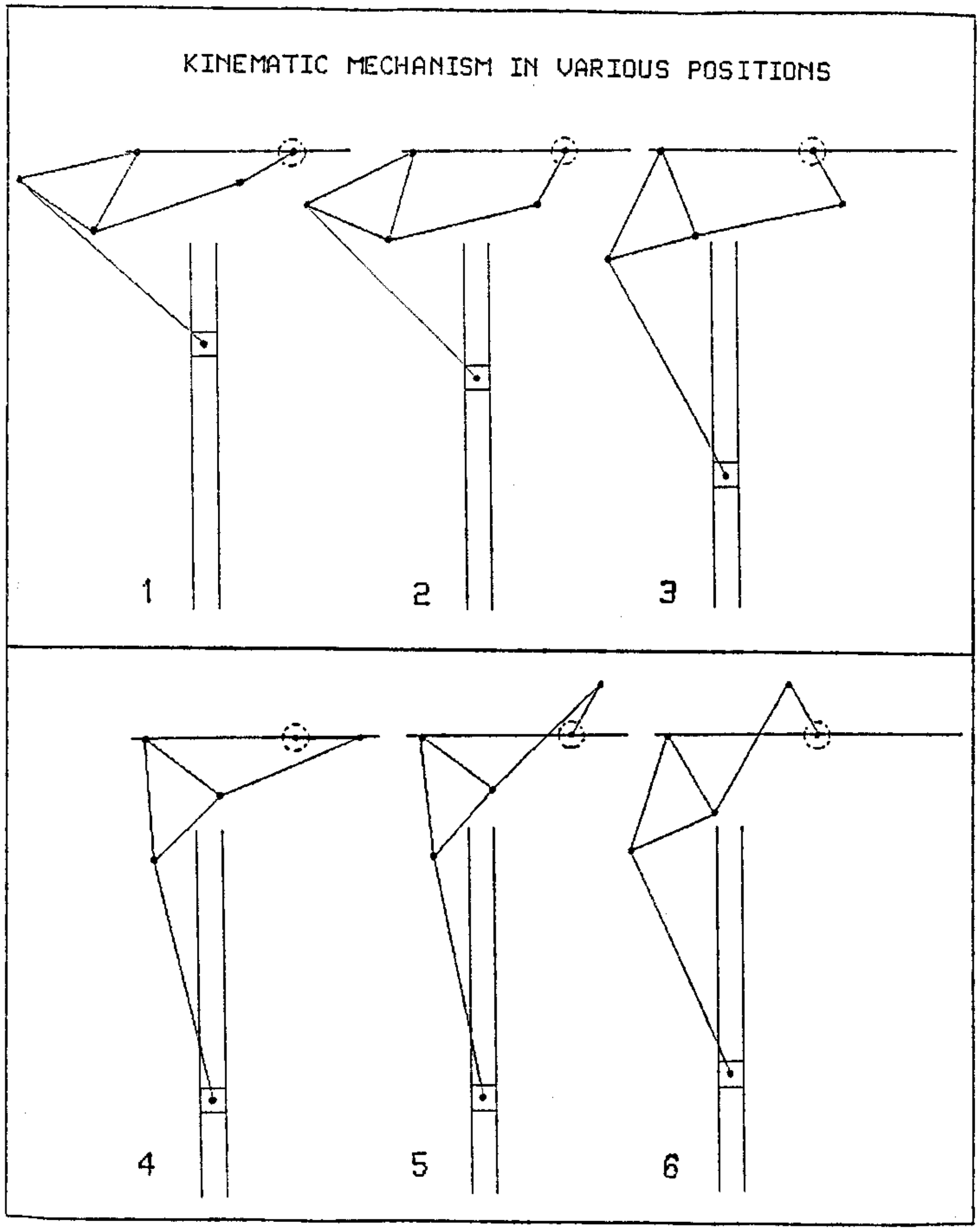


Figure 3

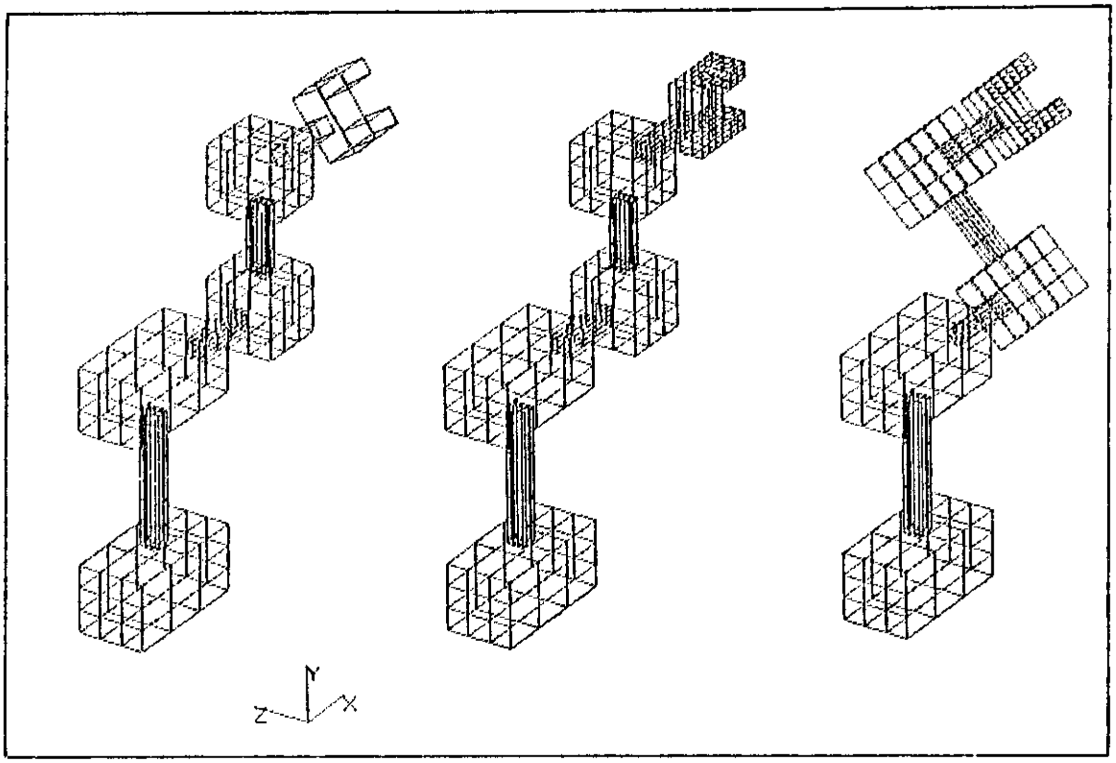


Figure 4

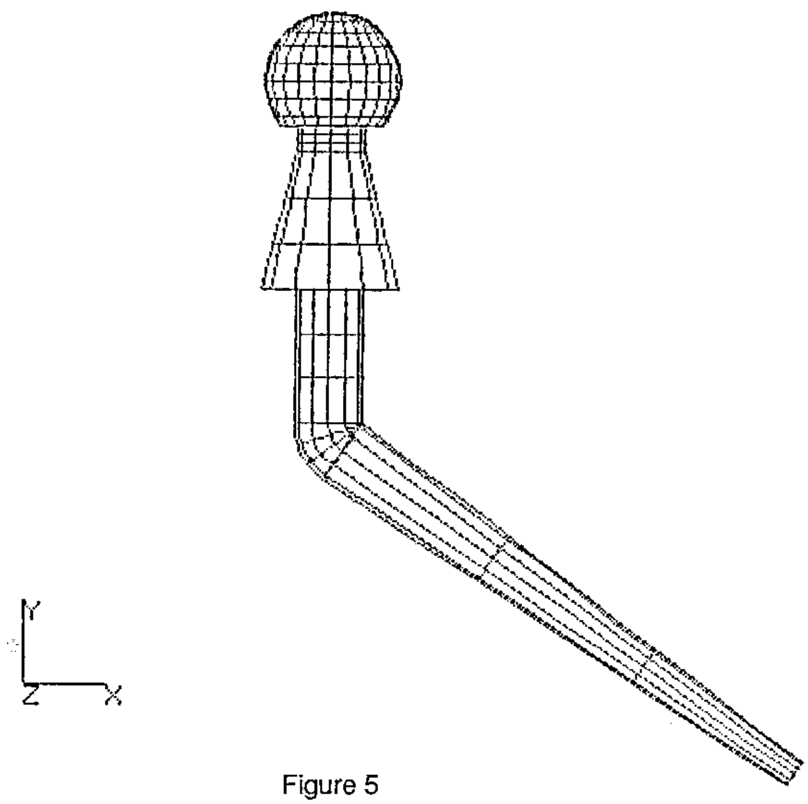
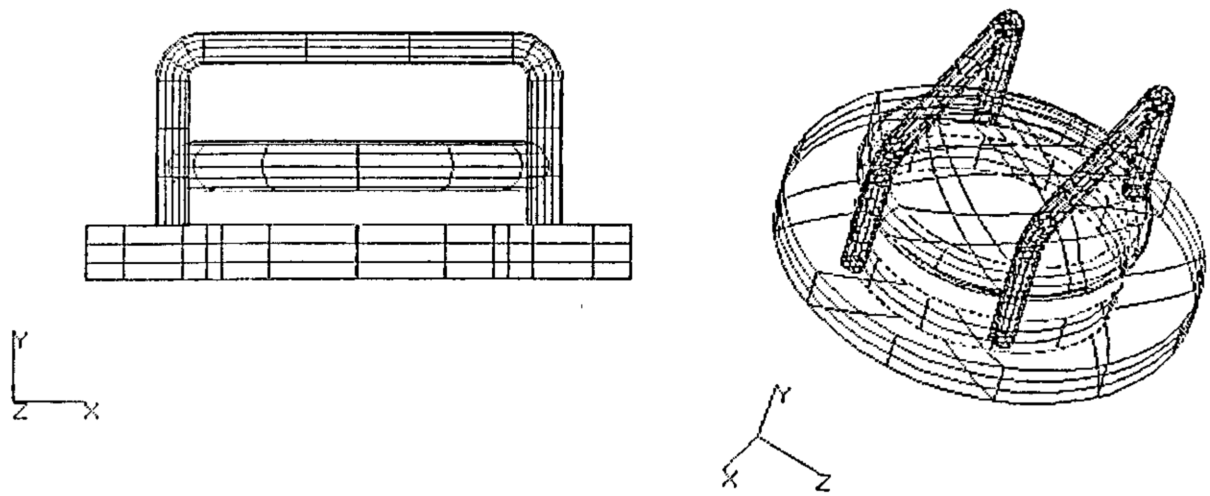
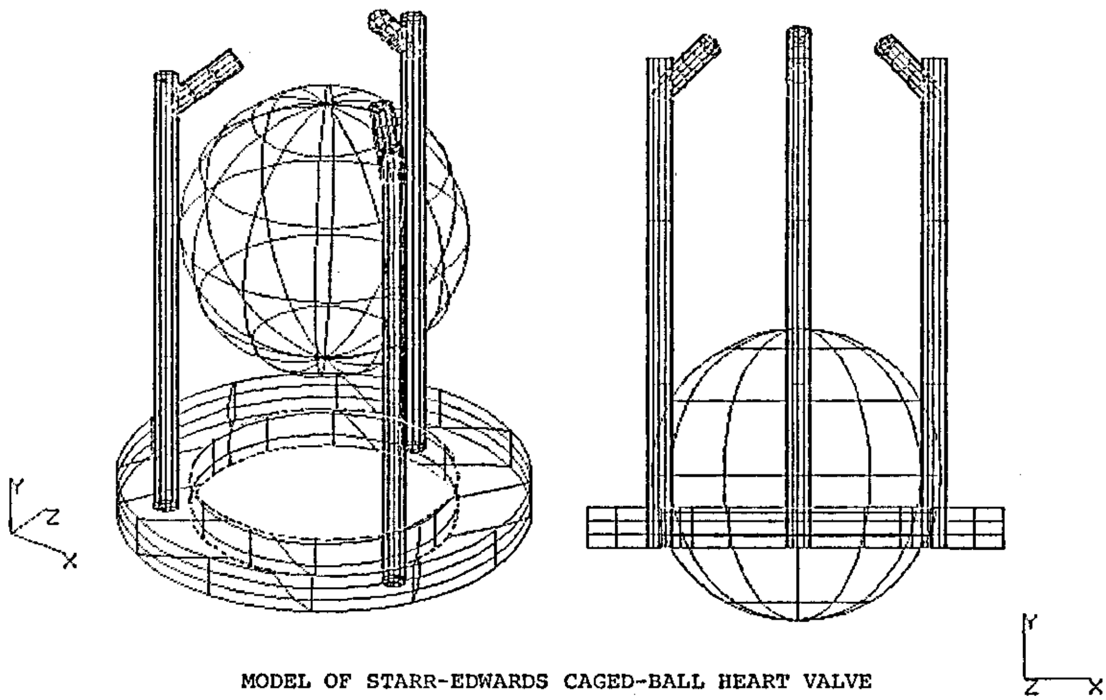


Figure 5



MODEL OF KAY-SHILEY SLIDING-DISK HEART VALVE

Figure 6



MODEL OF STARR-EDWARDS CAGED-BALL HEART VALVE

Figure 7

Bertoline

Continued from Page 22

There are some advantages to using a computer in the early stages of the design process. The use of a true "designer CADD" system will enable the user to make an idea explicit so it can be manipulated and evaluated. Stored images from related design solutions can be used for new design problems.

PROBLEMS TO OVERCOME

CADD has the potential to be a powerful tool for the whole design process. However, what is generally required to use a computer is a language which is foreign and unnatural to people (Hulteen, 1985). The difficulty in communicating with computers is a barrier that stands in the way of their full use. The answer to this problem is an interface between designer and computer that is easy for people to use. Even though computers were becoming more powerful the user interface did not seem to keep pace. Programming languages are being used that were developed 30 years ago. How many people are still using 30-year-old computer hardware? Unless this trend changes, the tremendous potential of the computer as the tool for the design process will be wasted because designers will not make the effort necessary to use them.

CONCLUSIONS

The advantage of using the computer is in its speed and not its quality. Designers must still have the basic mathematics, analyses, and visualization skills necessary to make sound decisions. In the hands of good designers, computers will become an effective tool. In the hands of others, computers will become the tool to create more visual garbage than the world has ever seen.

Although the design process itself may not radically change through use of computers, the methods used to teach the process will. Engineering graphics will play a vital role in making sure that the images created on a CADD system are not garbage. Visualization skills will become critical elements of every designer.
The total integration of the design process provides both challenges and opportunity to engineering design graphics.

REFERENCES

Bertoline, G.R. (in press). *AutoCAD for engineering graphics.* New York: Macmillan Publishing Co.

Groover, M.K. & Zimmers, E.W. (1984). *CAD/CAM: Computer-aided design and manufacturing.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Hooper, K. (1985). "Changing pictures/ Changing minds." In Whitney, P. & Kent, C. (Eds.). *Design in the information environment* (pp. 32-45). New York: Alfred A. Knopf.

Hulteen, E. (1985). "The interface to design." In Whitney, P. & Kent, C., (Eds.). *Design in the information Environment* (pp. 32-45). New York: Alfred A. Knopf.

Whitney, P. (1985). "Information, computers and design." In Whitney, P. & Kent, C. (Eds.). *Design in the information Environment* (pp. 32-45). New York: Alfred A. Knopf.

CAD EDUCATION: TEACHING COMPUTER-AIDED DRAFTING / COMPUTER-AIDED DESIGN AND NOW *CAD MANAGEMENT!!*

Michael D. Stewart
University of Arkansas
at Little Rock

INTRODUCTION

This paper addresses several facets of CAD Education. CAD Education is different depending type of curriculum and eventual occupation, position, or level of job within an industry the graduate is seeking. This paper also deals with the need for a new type of CAD Education — CAD MANAGEMENT— and how this can be done. The type of employment possibilities and demands for this type of occupation will be explored as well.

In today's rapidly advancing technological society, we have watched the engineering graphics area drastically change as CAD computers have been developed, computers that now proliferate the engineering, architecture and academic areas. These changes have affected all A&E areas. In the academic area, CAD has been discussed, debated, researched and finally accepted. The majority now see CAD as a viable tool in engineering graphics or at least as a tool to be used by engineering students so they will be capable of using CAD in industry.

Since CAD is being purchased and used in all areas of engineering, many companies are advertising for graduates with CAD experience and some are even going so far as to specify specific CAD software. The graduates of today's academic institutions need CAD exposure, education and experience to be competitive when they graduate. There is also a clear need for adequately prepared graduates in the area of CAD management. Especially in those smaller companies who are just computerizing and installing microcomputer CAD.

The question is, how much CAD knowledge and experience is needed by the graduate? Here is where the water begins to muddy a bit. At this point, we have to identify what type of educational program the student is taking. CAD today is being taught in junior and senior high schools, post-secondary vocational technical schools, community and other 2-year colleges and 4-year colleges and universities offering associate, baccalaureate and graduate programs in Engineering and Technology. If we consider that the CAD being taught in junior and senior high schools is general education, which is of course not true in many vocational programs in high schools, we can look at post-secondary and higher education as being where the emphasis in CAD Education is job oriented.

"There is a clear need for adequately prepared graduates in the area of CAD management."

In post-secondary vocational technical schools, and community or other 2-year colleges, diploma, certificate and associate degree programs are given in drafting or design technology. These students must be very proficient in manual drafting techniques, since they are being trained to become draftsman. They also must be able to use 2-D CAD software as a drafting tool as the industry continues to switch over drafting departments to computer based CAD systems. These graduates almost certainly will be CAD draftsman very soon, even if they are initially hired as a conventional draftsman. Their CAD education must be thorough in 2-D computer aided drafting, emphasizing all facets such as geometric construction, tolerancing, editing and manipulation, dimensioning, documentation, layout and plotting. Some CAD management issues need to be integrated into this level of training also. These graduates need to understand file management of the CAD data base, the use of daily operating system commands and plotting output procedures and operation. Although these people will have a CAD manager or supervisor over them, they will be expected to do these basic tasks involving file management and plotting on a daily basis.

In many 2-year colleges and some 4-year colleges and universities, associate degrees in engineering technology are awarded. These students receive associate degrees in many areas of engineering technology, i.e. mechanical, manufacturing, construction and electronics. These students will work in design related areas in engineering and should be ready to provide immediate service to their employer. With the design process, a proficient manual drafting and sketching background is necessary as well as the ability to use CAD to complete the design work. The amount of drafting that an associate degree engineering technology graduate does generally depends on the size of the company. Many smaller companies may use this person as a draftsman as well as a design technician. For this reason, manual and 2-D CAD drafting skills are necessary. This graduate should also have additional 2-D computer aided design and engineering education skills and experience. Since these graduates will be involved in the design process, their use of CAD will be split. A majority of their time will be spent doing CAD drafting and CAD design work. This depends on the engineering application area in which they are involved. Many of these technicians will be given low level CAD management responsibilities in addition to their normal duties. Such areas as data back-up and retrieval may be delegated to them. The smaller the engineering department, the more CAD management duties will be done by this level of personnel. Usually a CAD manager position at this level would be part-time at best and therefore most of the day-to-day operation will be delegated down the chain of command. CAD management issues involving the day-to-day office operation, file management, data back-up and retrieval procedures need to be integrated into their college courses. Other areas for which they may be responsible would be installing new software update versions, customizing CAD, plotter output scheduling, and various problems related to output. These CAD topics need to be included in a course or integrated into several courses throughout the associate degree curriculum.

"The engineering and engineering technology graduates are in the best position to become CAD managers or supervisors."

The 4-year colleges and universities offer engineering or engineering technology bachelor degrees. The engineering technology student generally is more hands-on oriented. The "how" is at least as important as the "why." These graduates need to be able to communicate their concepts and design plans in a proficient manner using both manual sketching, drafting and CAD skills. At this level, the use of advanced 2-D CAD as a design tool should be minimum. The optimum would be the usage of 2-D computer aided drafting skill as a background, and an understanding and hopefully skill in 2-D and 3-D computer-aided design software. This would allow the student to use CAD as a drafting tool as well as a design tool and see the full capabilities of CAD. Graduates of engineering technology programs work with engineers on application oriented modification and design projects, where real world problems are encountered and solved. They must be able to use the most current CAD technologies to solve these engineering problems.

The engineering students are in general analytically as opposed to manually oriented. These students should be visualizing in 3-D and using the most advance 3-D CAD software in surface and solid modeling and finite element analysis. Manual generation of drawings is a low priority, but the use of computer aided design and engineering tools is increasing with the advent of lower priced engineering design workstations. As a result, both the engineering and engineering technology graduate will be using more and more computer aided design tools as more computer-aided manufacturing (CAM) and computer-integrated manufacturing (CIM) are introduced into the industries. Lower cost hardware and software will make their use available at the design end, where before low cost CAD was simply a drafting tool. The only way to effectively educate these bachelor degree students with CAD is by the integration of CAD throughout the curriculum, not solely in engineering graphics.

The newest application of CAD educators must consider is the area of CAD MANAGEMENT. There is a high demand for graduates who have skill in this area in addition to regular CAD background. This graduate is especially in demand in the small and medium-sized companies who are just beginning to embrace CAD and CAM. This type of education extends beyond graphics and engineering design. It goes into a knowledge of different software, hardware, systems integration, programming, customization, productivity, organization and other management concerns.

The engineering and engineering technology graduates are in the best position to become CAD managers or supervisors. Engineering Technology graduates have an edge by having a more application oriented engineering background which gives them the necessary insight to the real world issues involved in CAD. Both engineering and engineering technology graduates, through their use of CAD as an integral part of the problem-solving design process, will have an application for the CAD tool and hopefully understand its function in an engineering office. Many basic CAD management skills should be integrated into the regular curriculum such as, file management, data back up and retrieval processes, plotting output operation andoperating system commands. The ability to load new or update CAD software needs to be stressed as it is such a part of CAD technology. In order to further complement the graduate's application engineering knowledge, specific courses should be taken to equip the person with management skills. Since the CAD area is rapidly changing, knowledge of CAD systems and management issues is important. The following CAD related topics should be covered: Disk operating systems, i.e. Unix, MS-DOS and Mainframe types such as Digital and IBM; hardware platforms, i.e. microcomputers, engineering workstations, minicomputers, mainframes; graphic displays and graphic controllers and accelerators; input and output CAD peripherals; graphic-oriented programming languages such as C, Lisp and assembly languages with Fortran and Basic for simple macro command programming and customization; micro processor interfacing techniques for connection trouble shooting and customizing of a computer system.

In the area of management such areas as: Office management, management information systems, distributed data processing and local-area networks, production management, and project and computer resource management should be topics which are covered.

Some of these topics can be added to existing CAD related

Engineering courses, and many are already incorporated in Electrical and Computer Engineering courses or Computer Science and Management courses. A minimal 3-hour course specific on CAD management with a realistic practical laboratory or cooperative education industrial experience would round out this CAD management emphasis.

This could be incorporated into any engineering, engineering technology, or computer science curriculum and be available to those students who wish to add this specific CAD enhancement to their program. This would, in many cases, extend the students' course work at the undergraduate level. For students deciding early to add this emphasis, taking these related courses as technical electives could minimize the impact considerably.

SUMMARY

In summary, many manufacturing companies, engineering firms, governmental agencies and related industries are just beginning to adopt CAD. There are expanding job opportunities available for a graduate with CAD management skills. There exists a void in most companies management of engineering CAD personnel. These are the companies who are looking for graduates with CAD related experience. A graduate with CAD experience and an emphasis in CAD management would certainly have no problem finding employment and advancement.

COMPUTER MODELING WITH FUNDAMENTAL 3-D PLOTTING SOFTWARE

W.D. Teter
University of Delaware

"The fundamental point-to-point plotting software is quite old by most standards but can continue to serve the students well."

INTRODUCTION

In 1974, Kearns [2] published a program that was, perhaps, the first of many similar programs developed in engineering graphics for display of a 3-D data structure. Other programs followed, such as DRAWL [3] and TRIDM [9], and a few years later, CUPID [4] and GRAPHIC I [10], which performed in much the same manner. A recent article by Anand, et al [1], discusses yet another such program that utilizes modern, mainframe system graphics support.

In 1979, this author similarly developed a program closely in the fashion of the Kearns program with extensive modifications. The major revisions included conversion from a 'batch' mode of operation with card input to 'disk file' storage of data and CRT preview of the graphics prior to hardcopy output. In addition, device control routines for scaling output were written, and menu functions were added to allow user input of quantities such as data file name, user name, type of drawing desired (orthographic, axonometric, perspective), viewing angles, etc. About five years ago, the program was converted to FORTRAN 77. The program has transcended three mainframe computers (Burroughs B7700, DEC-10 and VAX 11/780) and their corresponding operating systems. Currently, the software resides on an IBM 3081D with system graphics support from Precision Visuals DI3000.

This implementation at the University of Delaware is called PIGGE (Pictorial Image Generation for Graphics in Engineering)[5]. All of these point-to-point plotting programs are structured in a similar manner where *two* essential requirements must be fulfilled. First, the coordinate geometry of the 3-D object must be described as a listing of the (x,y,z) coordinates of each point on the object. Additionally, the 'connectivity' must be defined in terms of plot sequences [1, p.28 and 7, p.284-285]. With this standard data structure the software can be developed, and will plot the three-view orthographic projections and any number of axonometrics. Some of the programs (Kearns, Teter) will produce the one-point or two-point perspectives. Figure 1 shows output from a data structure produced by a freshman at the University of Delaware in 1979. (Note that the model is not complete as is evidenced by the student's awkward attempt to produce a pseudo-visibility effect.)

UTILIZATION OF THE BASIC SOFTWARE

The literature reflects that the fundamental 3-D display programs are not being used to their fullest capacity. There are few who would argue against the usefulness of these displays as an aid in learning visualization.

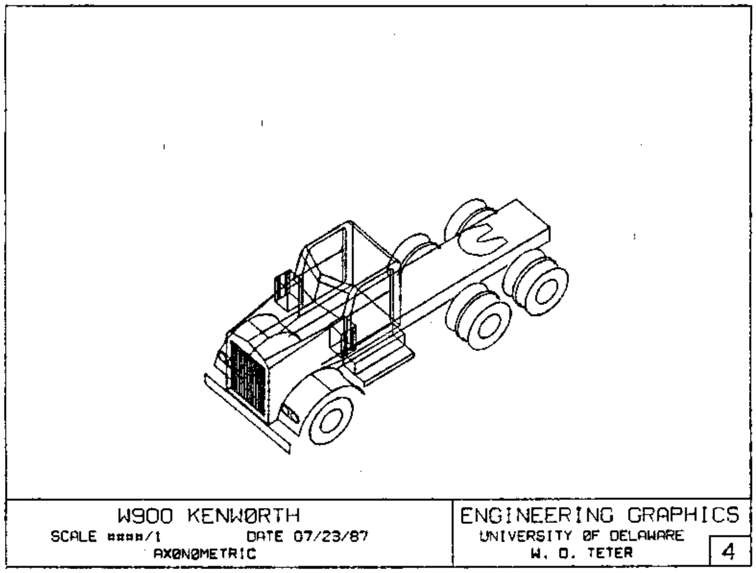


Figure 1

But, this basic software should be perceived as a tool for introduction to other aspects of computer graphics and computer-aided design. This author has developed several utility programs to enhance instruction in freshmen design with the inclusion of computer modeling concepts.

MODELING

An overview of 3-D graphics modeling is aptly presented by Barr and Juricic [6] where the important distinctions between wireframe, surface and solid models are described. As they state, "A 3-D wireframe model includes primitives defined in an (x,y,z) coordinate system. Wireframe models are relatively easy to create... ." In fact, they note that the orthographic projection is actually a 2-D wireframe model of the simplest form.

Thus, the fundamental concepts of computer modeling can be presented to include the ideas of the graphic entity (also important in CAD systems), primitives, and the procedure of merging entities

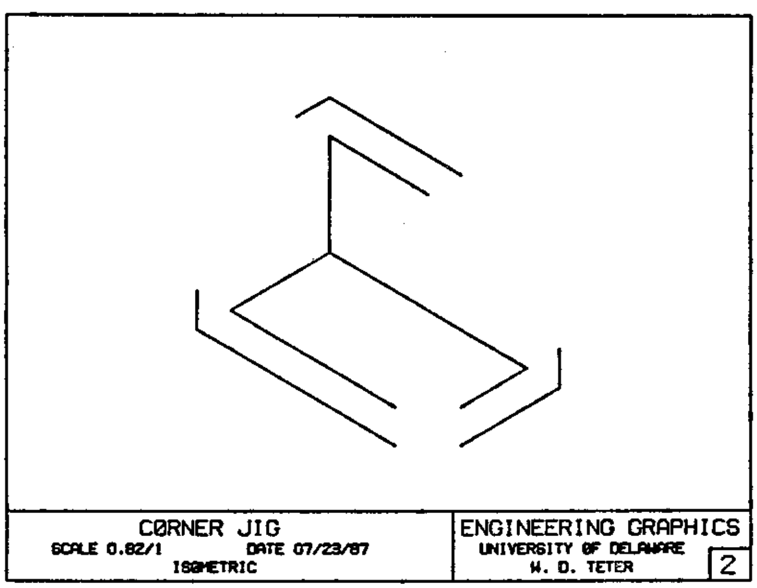


Figure 2

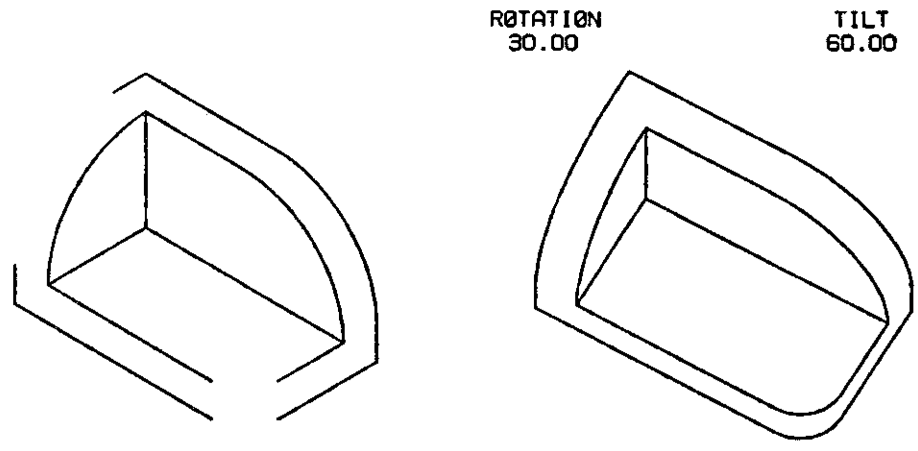


Figure 3

to create the desired model. The point-to-point plotting capability of the typical 3-D display program can easily produce the wireframe model.

The relatively expensive professionally written programs (e.g. Autodesk's "Engineer Works") are not necessary at the introductory level. The basic ingredient for simple wireframe modeling is already available to any group which has developed their obligatory point-to-point 3-D display programs. *That which is missing is software in the form of utility programs to enable the user to build the wires model.*

PIGARC

A utility program, PIGARC (Pictorial Image Generation of Arc Data), Teter [5], is designed to accept user input of center (x,y,z), radius and start-end point in degrees for a circular arc. The software, as a minor consequence, generates the coordinate data describing the arc.

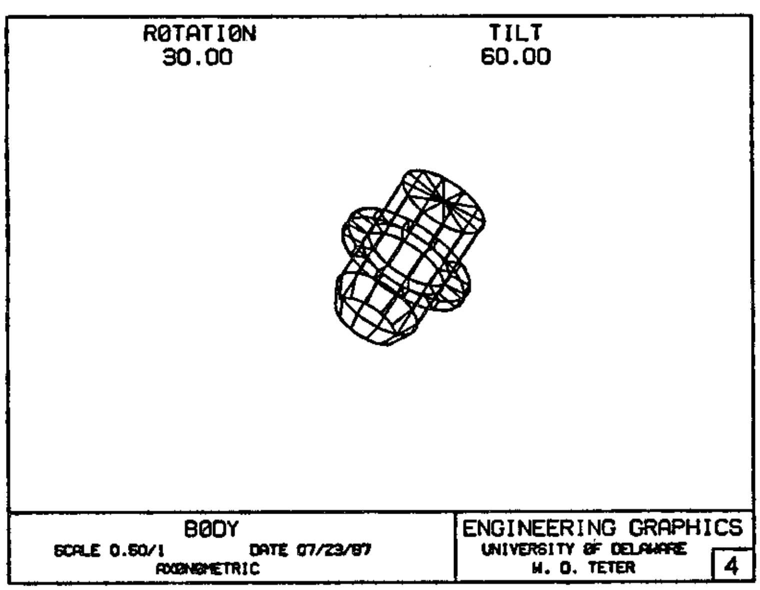


Figure 4

The *powerful* feature of this software is its ability to *merge* this data into any other file that is consistent in format for plotting by the 3-D program called PIGGE. This includes a merger of not only the coordinate data *but also the connectivity information.*

As a result, the user may define a primitive or simple structure sans circular arc data such as is shown in Figure 2. Then this primitive data file may be submitted to PIGARC which will add the necessary arc data and configure the new/modified file for plotting by the basic 3-D display program, Figure 3a and Figure 3b. The 'truck' model in Figure 1 was developed by a freshman engineering student in 1979 using similar software which was written by the student.

PIGMOD

Another versatile utility program, PIGMOD (Pictorial Image Generation for Modeling), Teter [5], is able to produce the data structure for a revolved spline to represent the wireframe of a surface of revolution. Since so many man-made and natural objects are of this type, this utility is extremely useful. The PIGMOD software generates the coordinate data *and* the connectivity description of a surface of revolution. The user must input radius values for points along a spline and the axial location. With the data structure properly defined for the point-to-point plotting program (PIGGE), the output of Figure 4 could be generated (the object is the reservoir section of a plotter pen).

In similar fashion, the cap of the plotter pen can be defined by PIGMOD and plotted by PIGGE, see Figure 5.

PIGMERG

As a final step, a utility program was developed called PIGMERG, Teter [5]. This software will process separate data files, representing graphic entities/primitives, and merge the files to form the data structure for a more complex object. Figure 6 shows the representation of the 'cap' and 'tip' sections of the plotter pen after the two separate entities were merged. Figure 7 shows the final model consisting of the merge of all three entities. The software includes a feature which allows for specification of the position of each entity after merging. In Figure 7, the three entities were left apart in exploded isometric form in order to enhance clarity. In a final merging of the parts (no figure is shown) it is possible to check for fit and interference. For example, the taper of the inside surface of the cap must match the taper of the tip section.

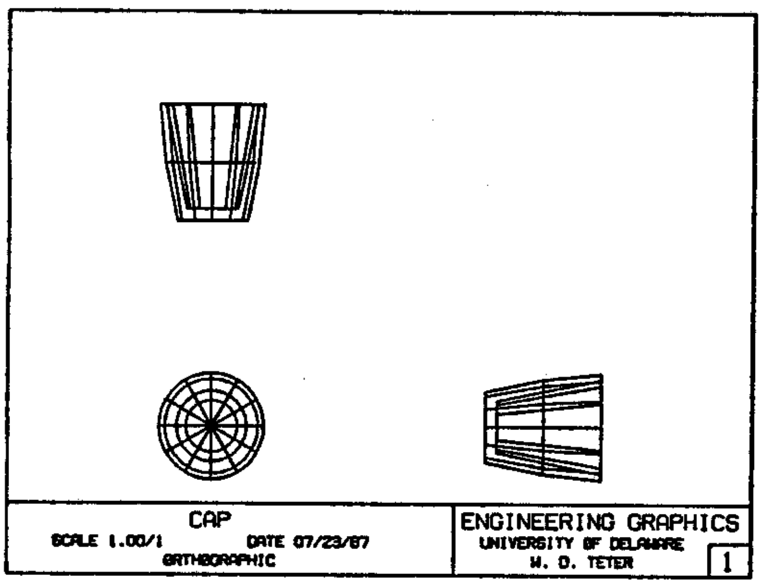


Figure 5

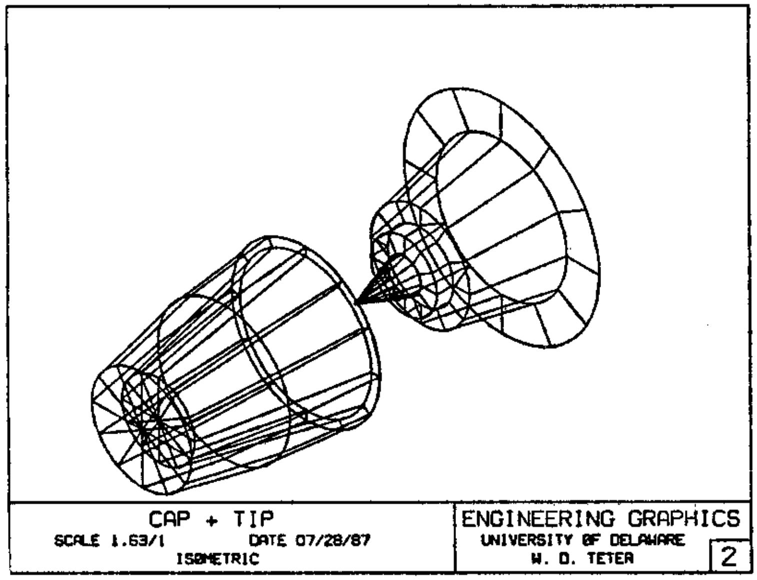


Figure 6

SUMMARY

The fundamental point-to-point plotting software is quite old by most standards but can continue to serve well. As computer plotting has become commonplace, these dated programs should be utilized in additional ways. The basic function as a tool for learning visualization can be further enhanced by expanding the scope of graphics instruction. The exercises in modeling concepts described herein produce a student who truly 'thinks in 3-D' and, as a byproduct, provide an introduction to an important area of computer-aided design.

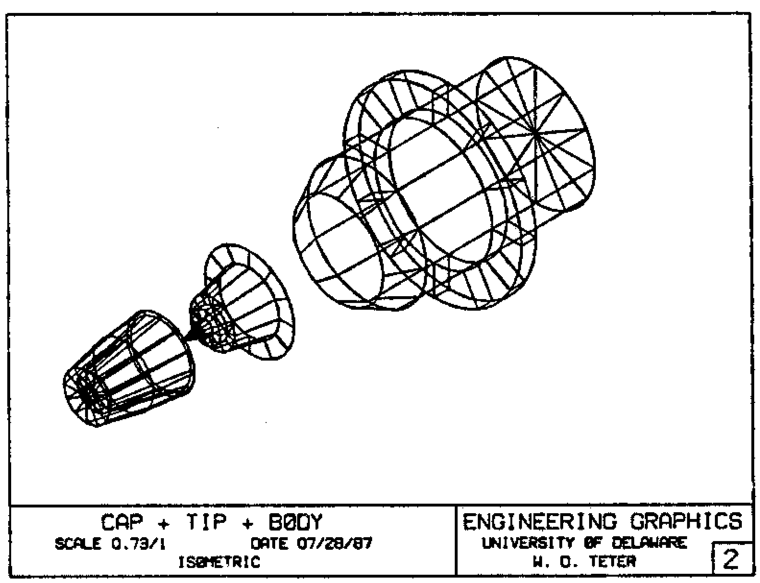


Figure 7

REFERENCES

1. Anand, V.B., Aziz, N.M., Agrawal, C., "Use of 3d Graphics to Improve Visualization Skills," *Journal of Engineering Design Graphics*, v51, n1, 1987.

2. Kearns, C., "A Computer Graphics Package," *Journal of Engineering Design Graphics*, v37, n1, 1973.

3. Pearson, W., "Computer Graphics with DRAWL and the Gould Plotter," Mississippi State University, 1979.

4. Ryan, D.L., *Computer Aided Graphics and Design*, Marcel-Dekker, 1979, pp. 187-197.

5. Teter, W.D., "User Guides for Computer Graphics Software," University of Delaware, 1979.

6. Barr, R.E., and Juricic, D., "Three Dimensional Graphics Modeling," *Journal of Engineering Design Graphics*, v50, n2, 1986.

7. Demel, J.T., and Miller, M.J., *Introduction to Computer Graphics*, Brooks/Cole, 1984, pp. 284-285.

8. Pearson, W., "Computer Graphics at Mississippi State University," *Journal of Engineering Design Graphics*, v38, n3, 1974.

9. Mosillo, F.A., "The Implementation of TRIDM at Chicago Circle," *Journal of Engineering Design Graphics*, v38, n3, 1974.

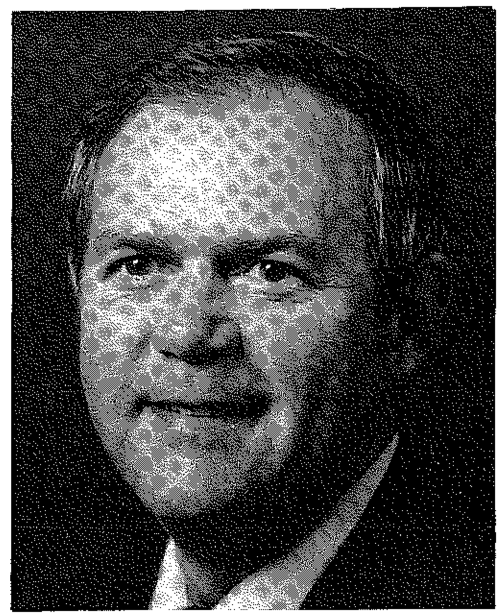
10. Jensen, Jon K., "Computer-Aided Instruction Using Student Interactive Visuals," *Journal of Engineering Design Graphics*, v45, n1, 1981.

11. Lang, Robert S., "Orthographic and Pictorial Drawing by Computer Graphics," *Journal of Engineering Design Graphics*, v47, n1, 1983.

12. Jenison, R.D., "Freshman Graphics," *Journal of Engineering Design Graphics*, v48, n1, 1984.

13. Sheridan, S., "The Scions of a Solid Modeler Mover into Industry," *Mechanical Engineering*, March, 1987.

14. Anderson, D., "Solid Modeling on a Micro," *Computer-Aided Engineering*, January, 1987.



8. All articles shall be written using Metric-SI units. Common measurements will be accepted at the descretion of the editorial staff.

9. Send all material in one mailing to:

Jon M. Duff
Editor, EDGJ
355 Knoy Hall of Technology
Purdue University
West Lafayette, IN 47907

REVIEW OF ARTICLES

All technical articles are submitted to the EDGJ Board of Review for blind review. This board represents national authority on graphic technology, engineering education, and technical specialties within engineering and technology. Authors will be notified as to the results of the review. Manuscripts may be accepted as submitted, accepted with provisions, or not accepted for publication.

The Journal reserves the right to refuse letters to the editor due to space constraints, because the material is potentially libelous, because the issues discussed are no longer of a timely nature, or because of a large number of similar letters on the same topic. Letters may be edited for spelling, punctuation, and style, and may be shortened or abstracted although meaning and tone will not be changed.

Circulation Manager
The Engineering Design Graphics Journal
The Ohio State University
2070 Neil Avenue Columbus, OH 43210