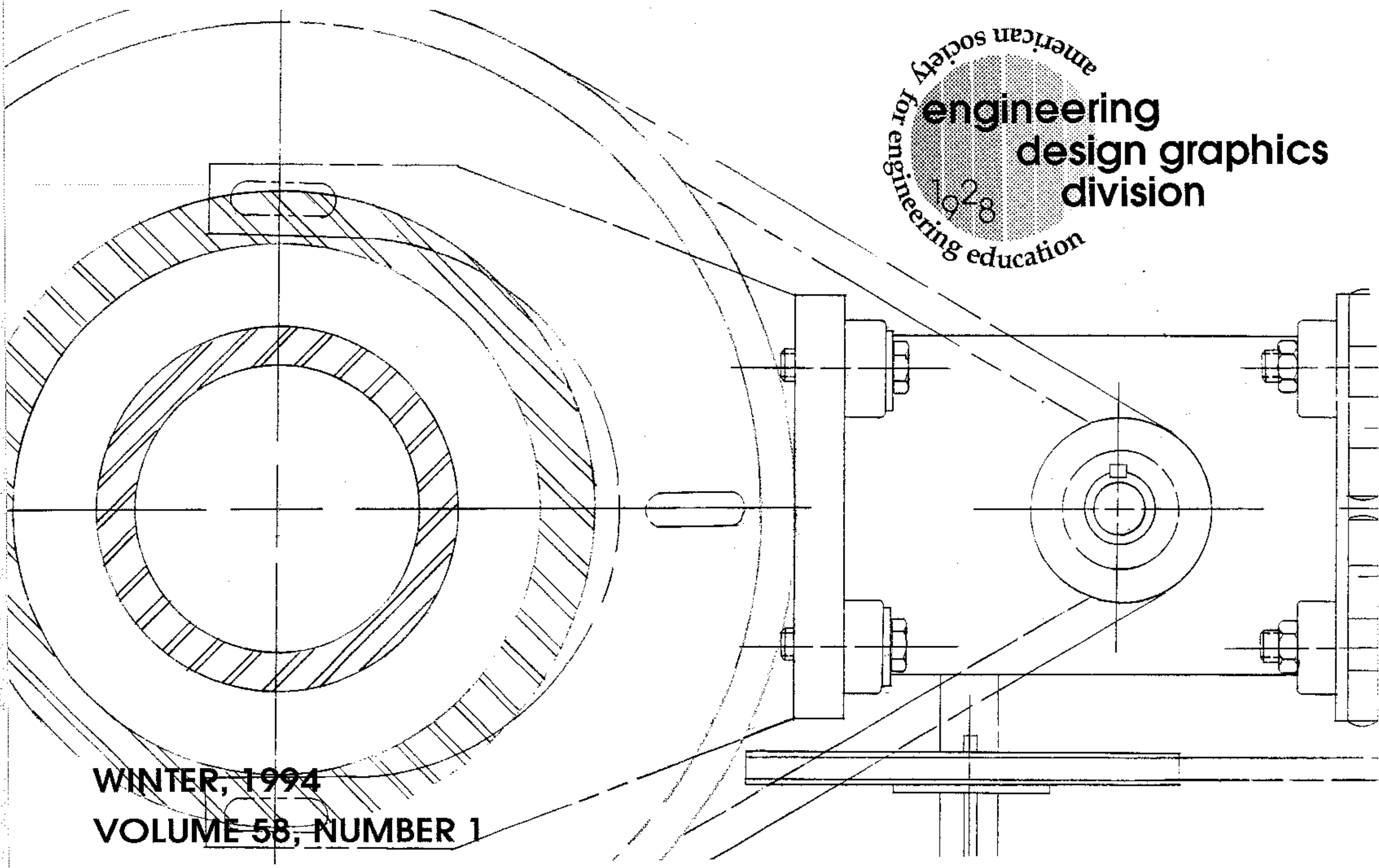
THE ENGINEERING DESIGN GRAPHICS JOURNAL



american society for engineering education
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1928

WINTER, 1994
VOLUME 58, NUMBER 1

ENGINEERING DESIGN GRAPHICS DIVISION
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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THE ENGINEERING DESIGN GRAPHICS JOURNAL

Volumn 58 Number 1 Winter 1994

The *Engineering Design Graphics Journal* is the official publication of the Engineering Design Graphics Division of ASEE. The scope of the Journal is devoted to the advancement of engineering design graphics, computer graphics, and subjects related to engineering design graphics in an effort to (1) encourage research, development, and refinement of theory and applications of engineering design graphics for understanding and practice, (2) encourage teachers of engineering design graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses, and (3) stimulate the preparation of articles and papers on topics of interest to the membership. Acceptance of submitted papers will depend upon the results of a review process and upon the judgement of the editors as to the importance of the papers to the membership. Papers must be written in a style appropriate for archival purposes.

ISSN 0046 - 2012

. . . from the EDGE

Engineering • Design • Graphics • Editor

It doesn't seem possible that it is now 1994. What really doesn't seem possible is that my mortgage will be paid off in 2001 which is only seven years from now. The year 2000 always seemed so far away, now it is just around the corner.

There are several things of interest in this issue that I would like to point out.

Mid Year Meeting

The call for papers for the 49th Annual EDGD Mid Year Meeting is on page 34. Deadline for abstracts is June 15, 1994.

EDGD Logo

Information about the EDGD Logo Contest is on page 35. The current logo was designed by a former member of the division and appeared sometime in the early to mid 1980's. The executive committee has discussed the possibility of a new logo several times and a contest was considered the way to go. This does not mean that we will abandon the current logo, but we hope to have something new for the 50th annual mid year meeting. The logo design contest is open to everyone, and there is no limit to the number of entries. Rodger Payne and Autodesk have graciously agreed to supply product awards for the top three logos. The deadline is May 15, 1994.

Summer School

EDGD Summer School. Del Bowers sent a questionnaire about the possibility of reviving the EDGD summer school. The response was interesting but the numbers were slim. If you didn't receive the survey, or didn't send yours back, there is still time. You will find a letter from Del and a copy of the original survey on page 40. He is very interested in your opinions.

Membership

One of our goals is to increase the membership of the EDG Division. If you know of individuals who are not members, but might be interested, please fill out the form on page 46 and return it to Moustafa Moustafa. He will send them information about ASEE and the Division. It is imperative that we maintain our membership.

Mary A. Sadowski

Editor

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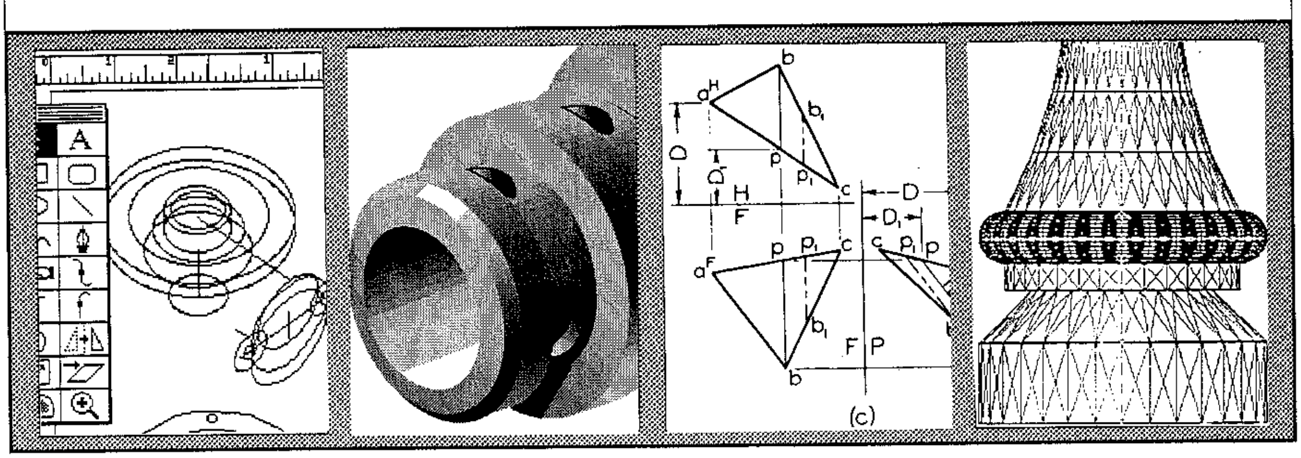
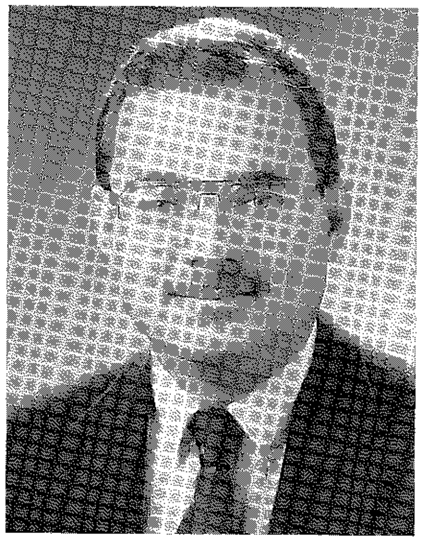
• *Cover Design by Teresa Forrester*



Creating Accurate Standard Axonometric Projections by Direct Construction Using Two-Dimensional PostScript® Drawing Programs

1993 Oppenheimer Award Recipient



Presented at the
Engineering Design Graphics
Mid-Year Meeting
Athens, Ohio
November 2, 1993

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Abstract

Modern practice relies on PostScript drawing programs to produce both line and shaded technical illustrations. When 3D CAD data is available, the model should be positioned in CAD and exported to PostScript to form the basis of the illustration. When 2D CADD data exists, it should be exported to PostScript and sheared into axonometric position. Otherwise, existing engineering drawings can be read and standard axonometric views constructed from a template of unitary cubes. PostScript illustrations are completed as engineering pictorials, line weight renderings, or realistically shaded images.

Modern Technical Illustration

Computer-created technical illustration has become the accepted practice in industries supporting construction, manufacturing, and service. In order to produce illustrations of the highest quality, programs are used which create graphics independent of target printer resolution. The most common programs print to PostScript language printers and use PostScript routines to describe line geometry, blends and shades, and text.

Technical illustration can be produced using a variety of methods and in fact, success is somewhat dependent on an illustrator's flexibility in using whatever method is appropropriate for a given job. The choice of strategy depends on the source of incoming data, the equipment available, and the abilities of the personnel. In order of flexibility and power, the methods are:

- 3-D engineering data (model geometry)
- 2-D engineering drawings (drawing geometry)
- video capture (trace over)
- photographs (trace over)
- paper drawings (direct construction)

Engineering model geometry provides access to any and all axonometric views. The illustration's accuracy reflects the model's accuracy. Two-dimensional drawings provide the accuracy of the 2-D drawing data but the views must be manipulated into correct pictorial position. However, much information usually contained on engineering drawings must be filtered out as it has no bearing on the illustration. Video capture allows a multitude of possible pictorial orientations as the camera is moved around the object while a photograph records but a single orientation. Both of these methods produce correctly scaled and oriented pictorials, axonometric with a telephoto lens and perspective with a wide angle lens. Both video and photographs are electronically traced to produce technical illustration linework. Lastly, traditional paper engineering drawings can supply the dimensions necessary for technical illustration but at marginal savings over traditional methods.

Importance of PostScript

PostScript is an interpreted language designed to describe the shape and position of textual and graphical elements on a page. The interpreter resides in the output device and either interprets PostScript code passed from an application program at a workstation or from the printer prep program. It is an example of a *page description language*—not the only page description language in use today, but certainly the most important in terms of technical documentation in industry and architecture.

PostScript is device-resolution independent. That is, the description of the page elements does not depend on program, display, or output device resolution. This represents a dramatic departure from how pages were described by pre-PostScript proprietary page composition hardware where the burden of page description was placed on the workstation computer itself. PostScript places the burden of page description on the output device, freeing the workstation to continue its tasks. This accomplishes several positive results: smaller, less expensive computers can be used to lay out documents and create illustrations, PostScript printers can be shared as network devices by several workstations, and only one PostScript license need be purchased per printer. PostScript has been used as a display language without great success partially due to the need for a separate PostScript license at each computer.

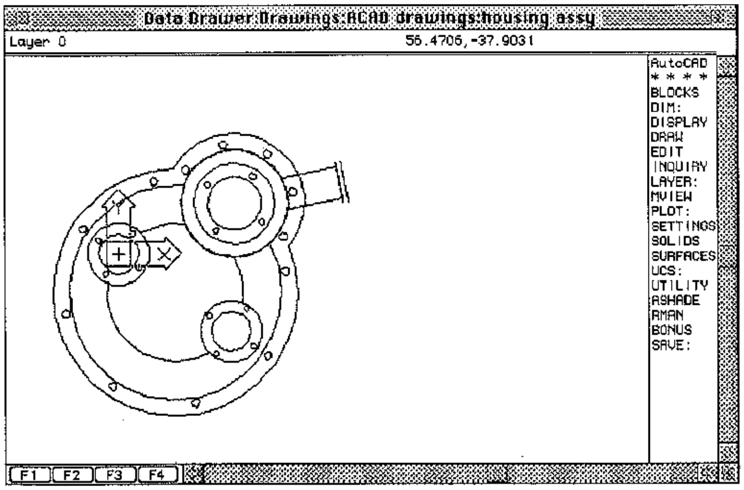
> " PostScript is an interpreted language designed to describe the shape and position of textual and graphical elements on a page."

Position of PostScript Programs

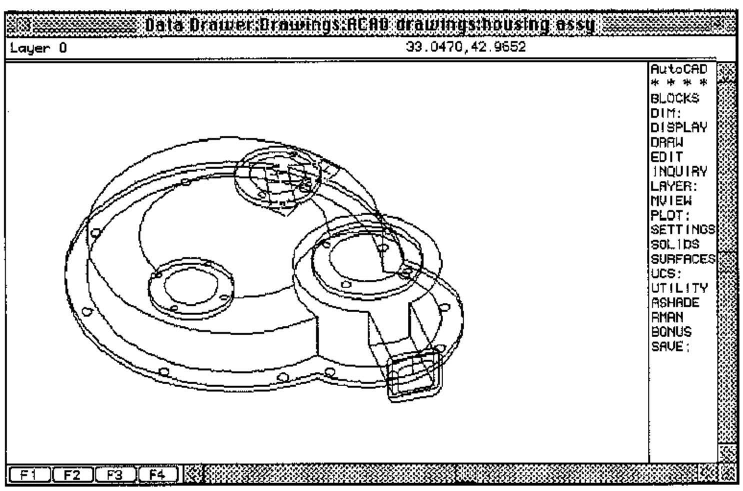
A PostScript drawing program makes use of the same graphic and text routines to create the page at the workstation as are used to print the page. PostScript code can be interpreted line by line without translation. The closer the program's code is to the printer's interpreter, the greater the chances of success. This is especially critical with programs that write their own version of PostScript and use a PostScript clone printer. Many commercial offices prefer Adobe Illustrator® sending Adobe PostScript® to an Adobe PostScript® printer for obvious reasons.

CAD programs do not create their graphics in PostScript because the function of CAD is not to describe pages. CAD models do, however, often find their way onto technical pages by being translated into PostScript code. However, such translations make use of few, if any, sophisticated PostScript text or graphic routines and generally result in smashed and vectorized 2D graphics. These PostScript images are generally unacceptable as finished technical illustrations.

The PostScript interpreter contains libraries of sophisticated graphic routines



CAD Geometry in Principal Position



CAD Geometry in Pictorial Position (1,.51,1)

Figure 1. CAD data in standard axonometric position.

that can result in stunning images. To make use of these routines, the graphics engine in the application program must be aware that they exist and in CAD, this is not the case. Translating a CAD model into PostScript makes use of only a small portion of PostScript. PostScript drawing programs, on the other hand, provide a direct handshake between what the illustrator envisions and what comes off on the page.

The success of technical documentation can be gauged by the technical accuracy and effectiveness of its images. It seems obvious then that a marriage between an accurate CAD graphics engine and a PostScript drawing program could produce images that have both technical accuracy and visual effectiveness. As of this writing, no such program exists.

PostScript Illustration Methods

From 3D CAD

In general, it is advisable to use a reliable 3D data base as the foundation for an axonometric drawing. In this case, all rotation of the data must be done in the CAD program because PostScript drawing programs are strictly 2D. For example, most companies standardize axonometric views so that they can be combined and updated easily. A view of the CAD model is achieved by azimuth and elevation angles or by specific viewpoint position. Figure 1 shows a model in principal position and with a view point positioned at azimuth=45° and elevation=20° (X=1, Y=.51, Z=1), resulting in a 20-40-40 dimetric view. This model can be exported in EPS, PICT, or CGM formats for editing in a PostScript program such as CorelDraw!, Illustrator, or FreeHand. See Table A for CAD viewing data.

Shearing From Orthographic Views

Shearing is found in many CAD programs and can be implemented in PostScript programs as well. Shearing is the process of producing axonometric faces by using scale, shear, and rotate transformations. This technique is advisable only if you have scaled orthographic views already in electronic form or if construction directly in pictorial would be laborious, as might be the case with gear teeth. Shearing produces close approximations of true axonometrics but requires extensive editing. You save time on construction but lose time on editing.

Figure 2 shows two examples of this shearing technique. In each, the first figures are the standard orthographic views, edited from 2D CAD drawings. The second figure shows the views sheared into position. The third figure shows the edited and completed pictorial. See Table B for standard view shearing data.

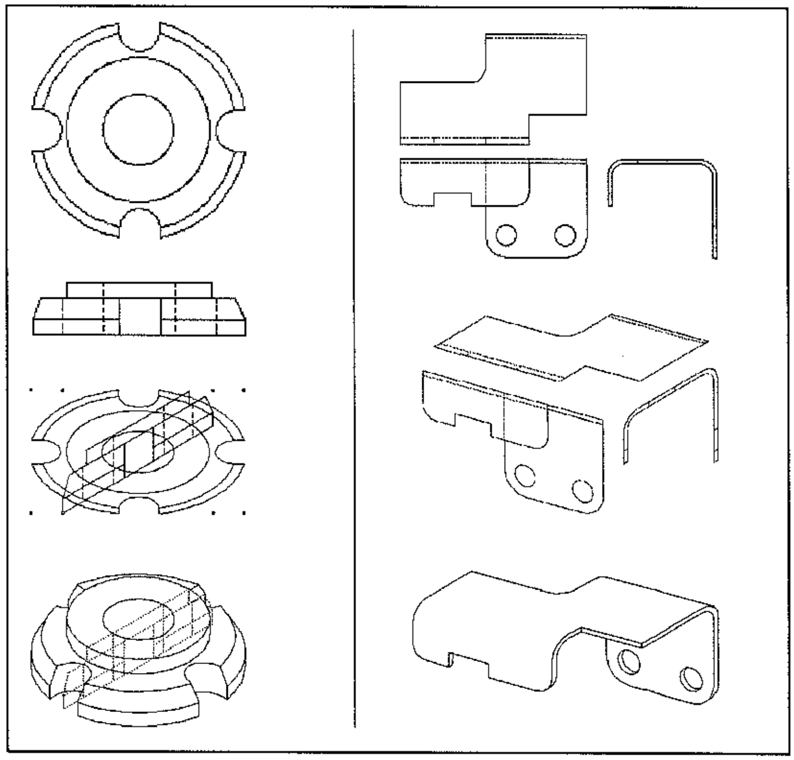


Figure 2. Views from 2D CAD copied, sheared, and moved into pictorial position.

Direct Construction

The previous discussions have set the stage for the most common PostScript axonometric technique: direct construction. Direct construction is appropriate when either 2D or 3D electronic engineering data is unavailable. (Remember with 2D data you can shear the views. With 3D data you can rotate the model in CAD and then smash it into 2D vectors for importing into the PostScript program.) The foundation for direct construction is the creation of a correctly scaled unitary axonometric cube with ellipses on the principal faces. The values for axis scales and ellipse exposures and angles can be found in Table C. Figure 3 shows a 20-40-40 dimetric cube template open in a rear window, with a construction window in the front. Lines and ellipses are copied from the template and scaled on the illustration. Because elements are already correctly foreshortened on the templates, full scale values can be used. Note that the construction geometry has been cop-

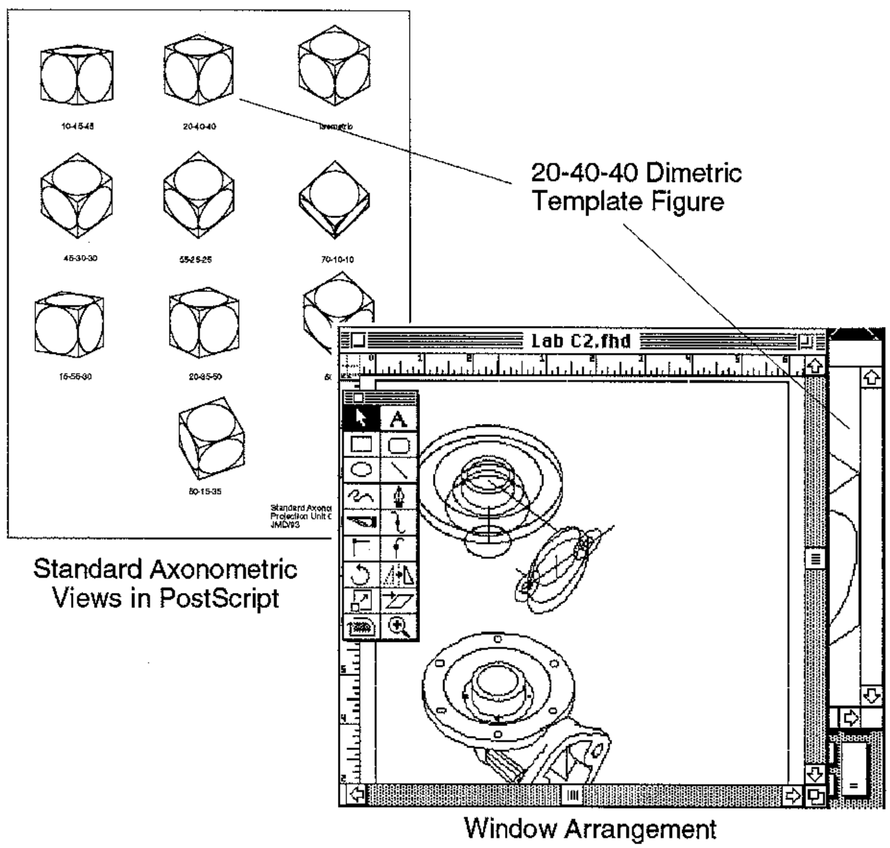


Figure 3. Elements from a dimetric template cube are copied and scaled in the construction window where they are scaled, moved into position, and edited.

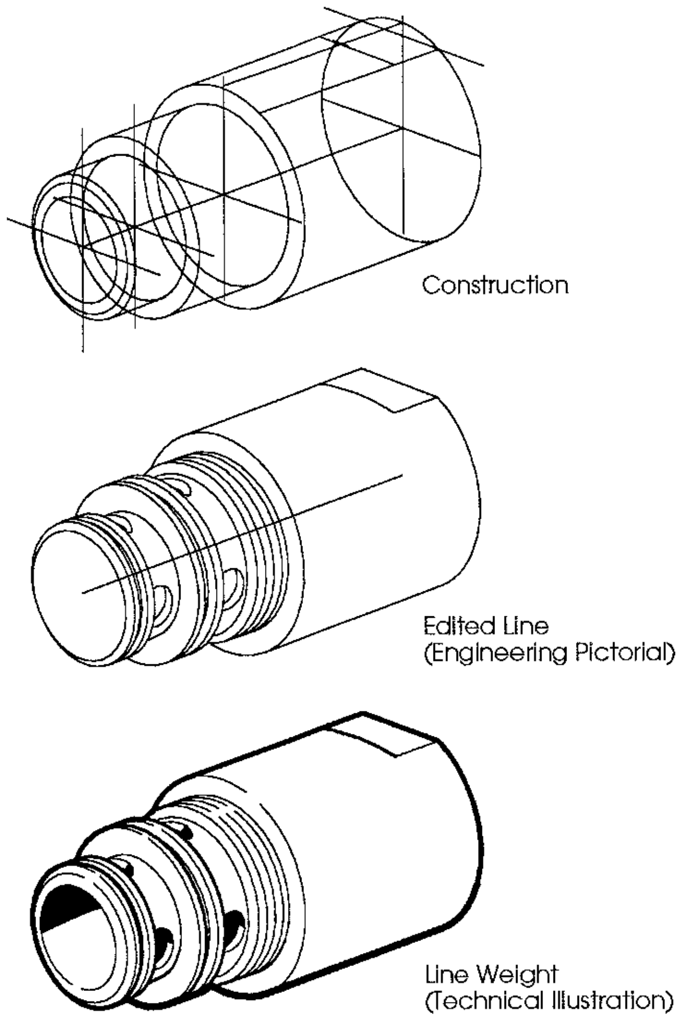


Figure 4. Unedited construction, engineering pictorial, and line weight technical illustration.

ied before editing for visibility. By keeping a full construction handy, one can recopy geometry as needed to complete the construction.

Line and Shade Styles

To make the construction into an illustration, the layout must be edited. Line styles are created and applied to lines on the illustration much as ink was applied with pens in traditional manual illustration. See Figure 4. Standard or custom blends can be applied to the areas to create a fully-shaded illustration as is shown in Figure 5.

Conclusion

A technical illustrator must be able to select the most appropriate tool for the job. If 3D model data is available, it should be placed into standard axonometric position and exported in a file format compatible with the target PostScript program. If 2D CADD data is available, it should be exported and sheared into standard axonometric faces. If only engineering drawings are available, illustrations should be constructed directly in PostScript using correctly scaled unitary cubes and ellipses.

Many illustrators find that they must be adept across three areas of graphics: CAD modeling, PostScript drawing, and

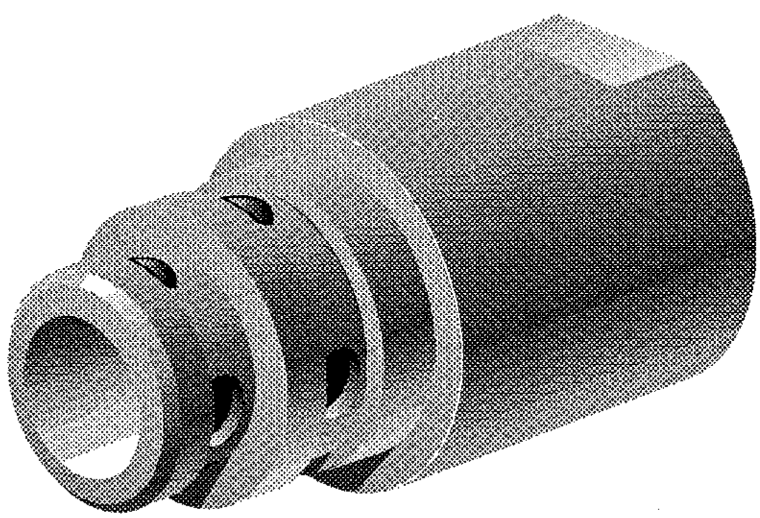


Figure 5. PostScript fills and blends with no outlines.

Tables

ELLIPSES	AXES	ROTATION		VIEW POINT		
H-L-R	L/R	Azimuth	Elevation	-Xw	Zw	-Yw
DIMETRIC						
10-45-45	9.5º/9.5º	45º	10º	1	.25	1
20-40-40	20º/20º	45º	20º	1	.51	1
ISOMETRIC	30º/30º	45º	35.266º	1	1	1
45-30-30	35º/35º	45º	45º	1	1.41	1
55-25-25	39º/39º	45º	55º	1	2.02	1
70-10-10	43.5º/43.5º	45º	70º	1	3.88	1
TRIMETRIC						
15-55-30	9º/24º	60º	15º	1.73	.53	1
20-35-50	24º/14º	36.47º	20º	.74	.45	1
30-50-25	15º/43º	61.53º	30º	1.85	1.21	1
50-15-35	60º/19º	23.66º	50º	.44	1.30	1

Table A - CAD Viewing Data for Standard Axonometric Views

SHEARING DATA FOR STANDARD AXONOMETRIC VIEWS					
Ellipses	Axes		Transformations		
H-L-R	L/R	Face	Vertical Scale %	Horizontal Shear	Rotation
20-40-40	20/20	Top	63.179	-50	-20
		Left	75.253	20	-20
		Right	75.253	-20	20
45-45-15	15/60	Top	96.592	-15	-15
		Left	96.592	15	-15
		Right	50.000	-60	60
Isometric	30/30	Top	86.602	-30	-30
		Left	86.602	30	-30
		Right	86.602	-30	30
50-30-25	15/30	Top	70.711	-45	-15
		Left	96.592	15	-15
		Right	86.602	-30	30
55-30-20	15/45	Top	86.602	-30	-15
		Left	96.592	15	-15
		Right	70.711	-45	45

Table B - Shearing Data for Standard Axonometric Views

AXIS AND ELLIPSE DATA FOR STANDARD AXONOMETRIC VIEWS						
View	Axes			Ellipses		
H-L-R		Angle	Scale	Plane	Minor Axis %	Rotation
10-45-45	V	90	.975	H	17.4	0
	L	9.5	.730	L	70.7	90+R
	R	9.5	.730	R	70.7	90-L
20-40-40	V	90	.930	H	34.2	0
	L	20	.740	L	64.2	90+R
	R	20	.740	R	64.2	90-L
Isometric	V	90	.817	H	57.7	0
	L	30	.817	L	57.7	90+R
	R	30	.817	R	57.7	90-L
45-30-30	V	90	.720	H	70.7	0
	L	35	.870	L	49.7	90+R
	R	35	.870	R	49.7	90-L
55-25-25	V	90	.610	H	81.9	0
	L	39	.910	L	41.9	90+R
	R	39	.910	R	41.9	90-L
70-10-10	V	90	.250	H	93.9	0
	L	43.5	.965	L	17.4	90+R
	R	43.5	.965	R	17.4	90-L
15-55-30	V	90	.970	H	25.4	0
	L	9	.860	L	81.9	90+R
	R	24	.570	R	49.7	90-L
20-35-50	V	90	.950	H	34.2	0
	L	24	.670	L	57.1	90+R
	R	14	.835	R	76.6	90-L
30-50-25	V	90	.670	H	49.7	0
	L	15	.870	L	76.6	90+R
	R	43	.920	R	41.9	90-L
50-15-35	V	90	.640	H	76.6	0
	L	60	.810	L	25.4	90+R
	R	19	.970	R	57.1	90-L

Table C - Axis and Ellipse Values for Standard Axonometric Views

Stereolithography: Fast Model/Prototype Making with CADD at the University Level

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Abstract

The time required to generate models of new or redesigned parts is key to maintaining a competitive advantage in the manufacturing environment. The increased use of computer-aided design and drafting (CADD) has significantly reduced design time, but the formation of a model representing the part is still expensive and time consuming. Depending on the complexity, prototype parts can cost in excess of $100,000 and take more than four weeks to manufacture. To address the need for the generation of models with reduced turnaround time and a concomitant decrease in expense, the new technology of solid imaging and model/prototype making has developed.

Stereolithography, a promising new technology, may help make the leap to designer-directed construction of 3-D models and prototypes. Stereolithography (3-D printing) permits the use of computer-generated designs and associated databases in the construction of plastic models.

The paper presentation provides descriptive narrative and graphical illustrations as to how a major Michigan university has integrated stereolithography and solid modeling methods into its design and engineering graphics, engineering technology, and computer-integrated manufacturing programs and courses.

Educational Process Advantages

The use of computer-aided design and drafting (CADD) has matured over the past two decades to provide for exceptional product design and engineering documentation capabilities. The prices of many systems have nearly been cut in half or their capabilities have more than doubled over the last two to five years. Computing capabilities speed designers and manufacturers from concept to product by user-friendly interactive methods. What had been missing was the ability of the designer to construct accurate models or prototypes without the painstaking time requirements of special hand- or machine-built parts. University engineering and technology programs are just starting to address these concerns. That problem has now been partially eliminated by developments of the last six years.

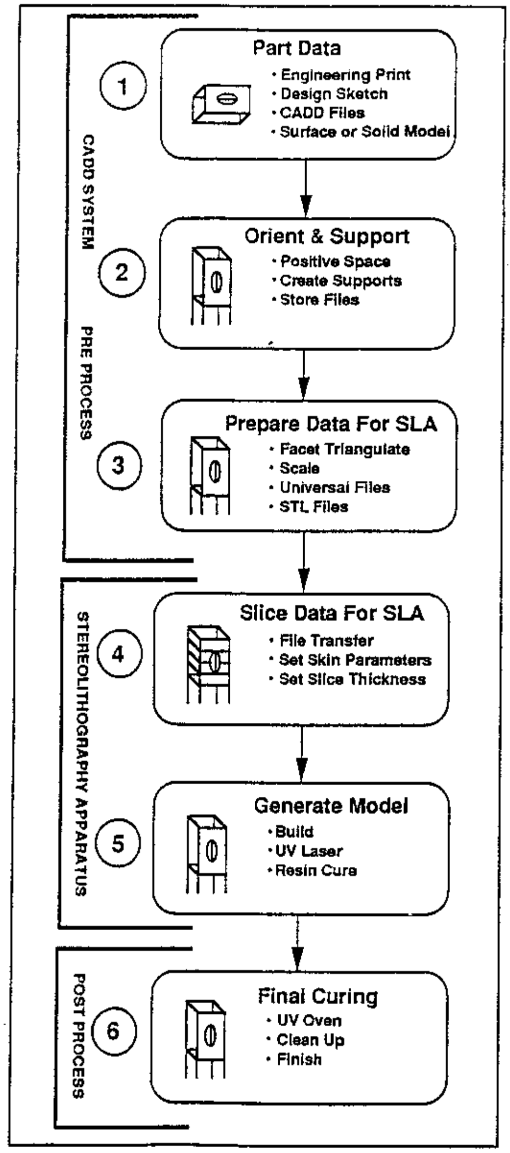

Figure 1. The Stereolithography (SLA) process.

Stereolithography, a promising new technology, may help make the leap to designer-directed construction of 3-D models and prototypes. Stereolithography (3-D printing) permits the use of computer-generated designs and associated databases in the construction of plastic models. This process can be completed often within hours and usually within a very small fraction of the time required in a standard model/prototype shop operation.

Stereolithography model/prototype development:

- Provides aesthetic and concept models or prototypes within just a few hours to a few days.
- Allows for improved customer acceptance because the buyer can visually inspect and hold a proposed new design.
- Permits greater design flexibility and improves design verification.

Form, fit, and function verification tests can be performed earlier in the design process with an actual physical model, reducing the number of costly engineering change orders. This capability improves the product's final production functionality and quality.

Conceptual 3-D models allow designs to be finalized much faster. Stereolithography produces models in much less time than conventional methods. By eliminating the hand tooling normally associated with prototype production, design flexibility significantly increases. This results in reduced costs and an improved product design.

There are many successful application including:

- Injection molding masters
- Investment casting masters
- Automotive prototype components
- Medical uses for creating body parts/replacements
- Wind tunnel models
- Electrical connectors

Design review prototypes provide for quick understanding of the state of the current design, resulting in valuable feedback. Fit can be verified by placing or assembling the prototype with other components in a subassembly, checking clearances, and identifying interference problems. Function tests can range from aerodynamic testing in wind tunnels to using the model in human engineering studies. CAD/CAM/CAE databases, gaining popularity as the primary definition of the product, can also be verified since the data is used directly to create the part.

Process Description

Stereolithography links engineering and manufacturing, allowing for optimizing the part for function, while simultaneously reducing manufacturing costs and schedules. By accurately describing complex geometry, stereolithographic parts can help contract shops bid on jobs and reduce problems interpreting engineering drawings on the shop floor. University students need to utilize these processes as part of their course requirements.

Figure 1 depicts the process flow of a stereolithography apparatus (SLA) system. The concept is relatively simple. The design is completed in a CADD system and is downloaded to the SLA equipped with a control unit.

Basically the process allows a computer to slice the 3-D design data into very thin sections. A laser is then directed to trace each section onto the surface of a liquid photocurable resin pool. The laser's ultraviolet light causes the resinous polymer to harden, thereby creating a thin slice of the model/prototype. After each pass of the laser, an elevator stage platform drops the surface to a lower level so the next layer slice can be created on top of the previously cured solid layer.

A part slice layer at a single depth is cured by the scanning UV laser beam which moves back and forth on the surface in the outlined shape of the object. The elevator stage platform upon which the model is being constructed drops the required amount for the slice layer thickness. It is like stacking very thin slices of bread on top of each other to form a vertically standing loaf of bread. Figure 2 illustrates a cross section through the basic SLA vat.

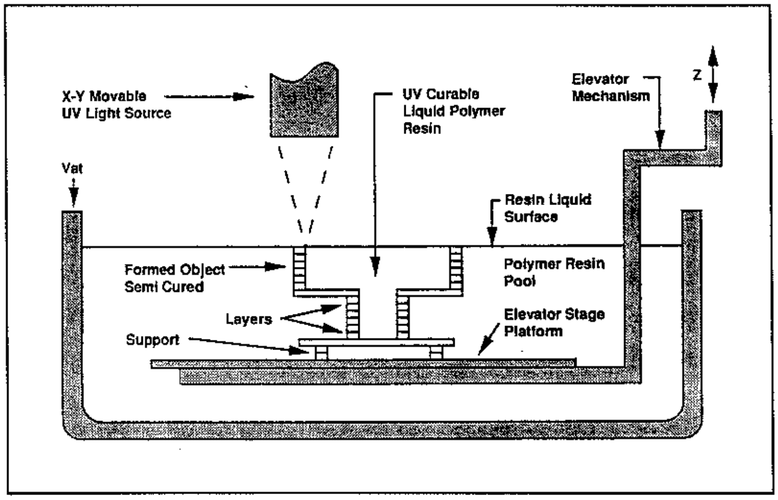

Figure 2. The basic diagram of how Stereoligraphy works.

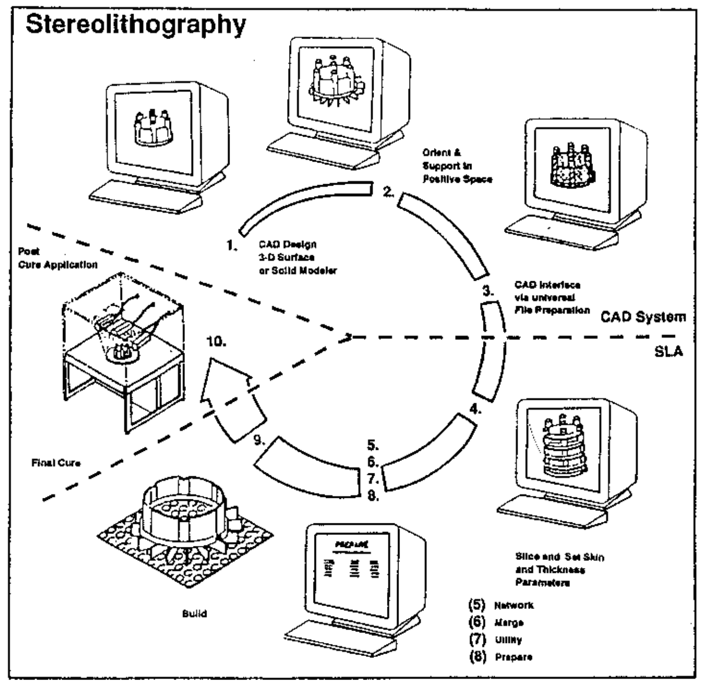

Figure 3. The steps from CAD part designing to cured model.

Figure 3 shows the steps necessary to prepare a scale model of an automotive distributor cap. The first step is to accomplish all the design requirements via CADD. The object is then arranged and supported in positive space (x,y,z). Special care is taken to build the CADD database as a 3-D solid or surface model. The CADD model is then surface triangulated and special universal transfer files are written. The files are then passed to the SLA for slicing and merging the object with its supports. The build process with the ultraviolet laser is then completed with a manual clean-up process and a final cure in an ultraviolet oven.

Stereolithography places no limits on the geometric complexity of the final model/prototype design, but there are physical limitations. The resin polymer vat presently allows for a 20-inch cube as the maximum size for an individual part or assembly buy

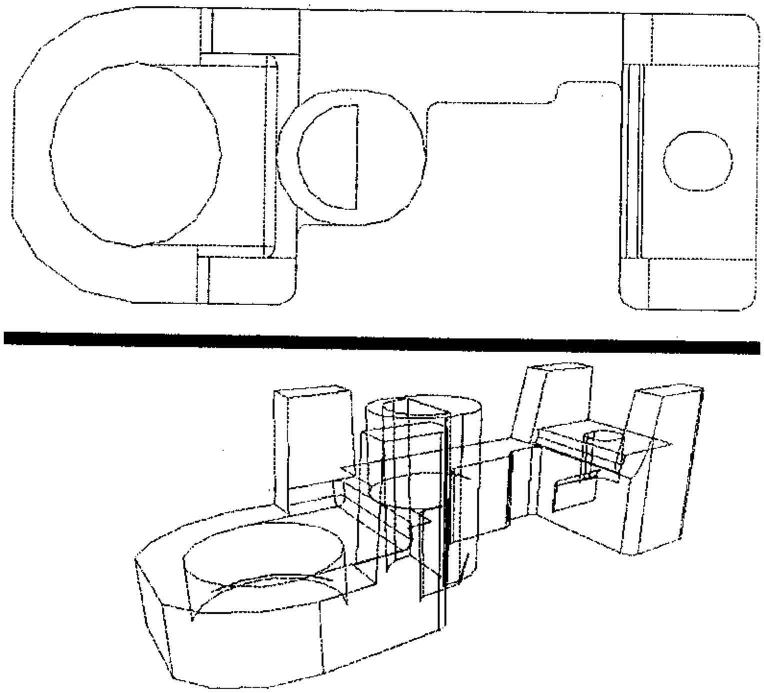

Figure 4. CADD model developed using 3-D solid/surfacing capabilities.

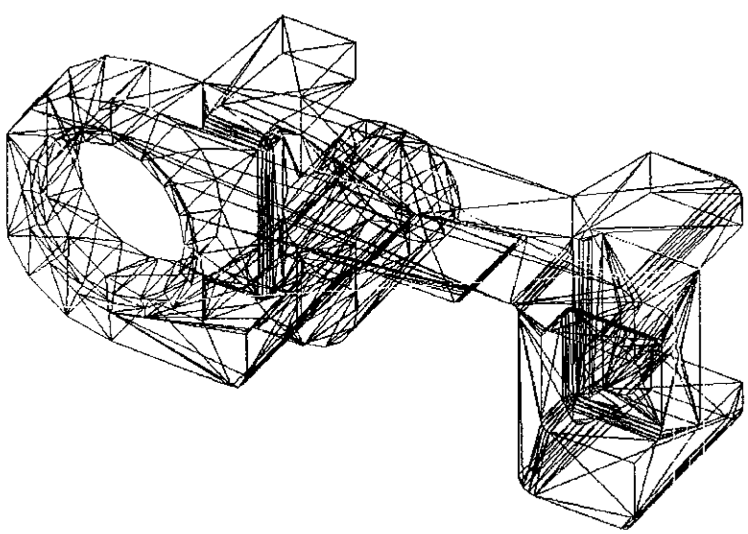

Figure 5. Surfaces triangulated in preparation of special universal files.

many cured pieces can be joined later to create a much larger object. Accuracy is typically on the order of 0.020 inch with 0.005 inch achievable. Vat sizes will likely increase beyond 50-inch cube capability within the next few months.

Departmental/Student Utilization

The Department of Industrial and Engineering Technology at Central Michigan University offers a number of majors under a B.S. degree program. The students enrolled in the following majors will utilize and observe the stereolithography process:

- Computer-Integrated Manufacturing
- Mechanical Engineering Technology
- Manufacturing Engineering Technology
- Industrial Technology/Design and Engineering Graphics Concentration.

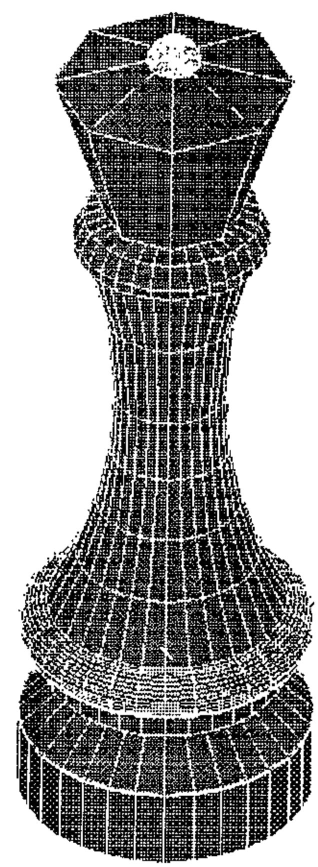

Figure 6. Solid model prior to triangulation showing faceted surfaces.

Courses which are part of the majors and that provide an introduction to or hands-on experiences include:

- Computer-Aided Drafting
- Computer-Aided Design
- Advanced Computer-Aided Design
- Computer-Aided Engineering
- Manufacturing Systems

Activities included in the courses vary but are integrated content. Additionally, independent studies can be arranged to meet special project requirements or in support of consulting activities. Representative activities for various courses include:

- Constructing 2-D profiles for sweeps
- Developing gear prototypes
- Designing compressor parts
- Group development of chess set masters
- Constructing investment casting masters
- Developing sand casting patterns
- Designing engineering textbook illustrations/photographs
- Creating SAE energy efficient vehicle prototypes
- Constructing miniature wind tunnel models
- Creating master parts for development of NC/CNC tooling/universal fixtures
- Providing regional industries with a prototype/modeling contract service

Student Examples

As examples, the graphic CADD screen images for actual student design problems are illustrated in Figures 4 through 11. Figure 4 illustrates a forged part designed in a 3-D CADD system, and Figure 5 shows the object surfaces triangulated and positioned in positive space. The base support structure is not shown in order to clarify

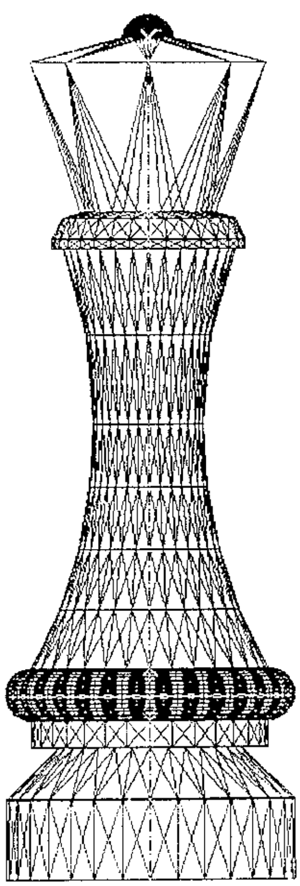

Figure 7. Triangulated surfaces of student design project.

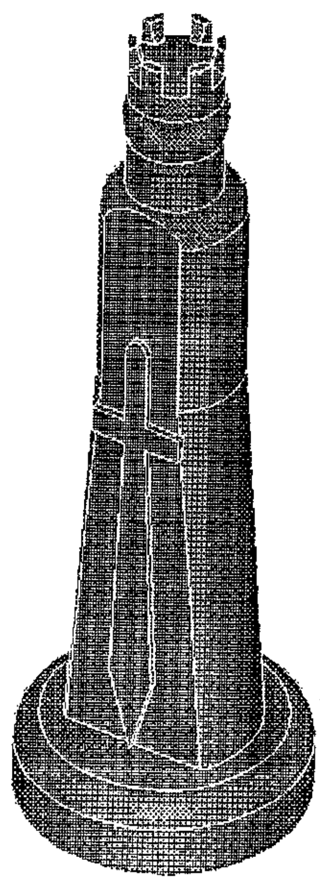

Figure 8. Solid model prior to triangulation showing boundary representation.

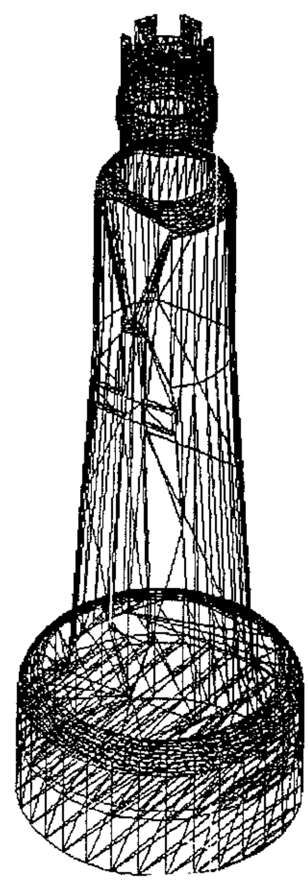

Figure 9. Triangulation of student generated solid model.

the illustration. Figures 6 through 11 show results of the CADD/SLA interface as used by Central Michigan University students.

University Sources

3D Systems, Inc. of Valencia, CA, has developed the first marketable stereolithography apparatus. Hundreds of their systems are used by numerous organizations including automotive and machinery manufacturing, electronics and consumer products, medical implants, and art and design schools. Stereolithography is generating considerable activity from other companies wishing to cash in on its development. For example, DeSoto Chemical Company has built its own modeling machine and is developing a special service company, and Sony Corporation has sold its own machines in Japan. Quadrex, DSM, Mitsubishi, MIT, Helisys, Stratasys, and EOS are also involved in the development of this technology. This sophisticated technology can play an important part in reducing the time it takes to get a product to market. However, personnel must receive the necessary training before any company can reap its full benefits. Universities will increasingly be involved with this new technology.

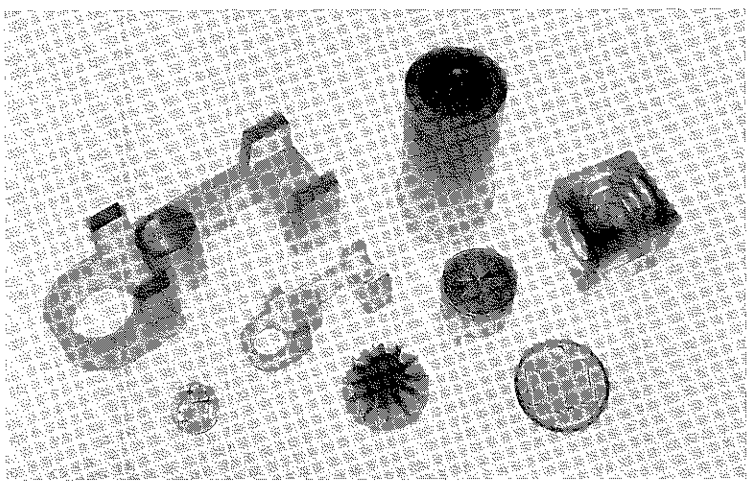

Figure 10. Examples of student design problems after SLA modeling.

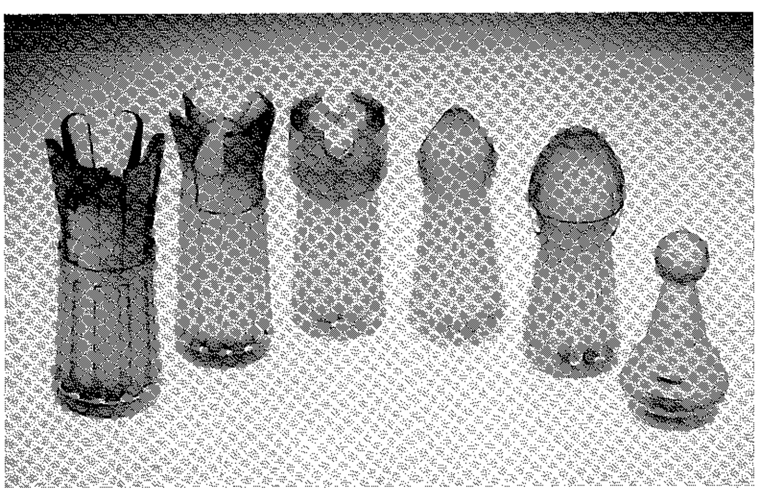

Figure 11. Student design team presentation prototypes.

The following companies provided technical information used in this article:

J.H. Young Company, Inc.
Engineering Services
8 Symington Place
Rochester, NY 14611
(716)235-7698

3DSystems, Inc
26081 Avenue Hall
Valencia, CA 91355, (805)295-5600

Laserform, Inc.
1091 Centre Road, Suite 270
Auburn Hills, MI 48326
(313)373-4400.

The Society of Manufacturing Engineering/Rapid Prototyping Association, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930, (313) 271-1500 can provide professional association benefits and information.

Selected References

Bibliography of Rapid Prototyping Resources 1990-1993 (1993).
Dearborn, MI: Rapid Prototyping Association of The Society of Manufacturing Engineers.

Medler, D.K. (1990). *Stereolithography: A Primer. Automotive Engineering*, 98 (12).

Nee, J.G. (1991). Stereolithography: Fast model/prototype making with CADD. *The Journal of Applied Manufacturing* Systems, 4(2), 61-65.

Teague, P.E. and S.L. Billings, (1993). Prototyping expands design's portfolio. *Design News*.

USING PICTORIAL GRAPHICS TO ENHANCE DESCRIPTIVE GEOMETRY INSTRUCTION

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Abstract

For many years, traditional descriptive geometry courses have depended solely upon the principles of multiview projection for presenting the course subject material and for solving problems. Today, many engineering and technology students are not prepared in multiview projection skills when they enroll in descriptive geometry courses or attempt to obtain a descriptive geometry solution. To assist these individuals, the technique of solving problems in pictorial format using descriptive geometry concepts has evolved. It is anticipated that using this technique will accomplish dual objectives. It will not only serve to reinforce the related multiview principles, but, also stimulate the development of depth perception and visualization ability. Both these abilities are essential to creative design. This paper will present five pictorial techniques presented in the authors textbook, Descriptive Geometry, and compare them graphically to the parallel multiview projection techniques. Explanations of the multiview projections solutions will not be presented, but such explanations can be found in the Paré, or any other Descriptive Geometry textbook.

Lines In Planes

Figure 1 shows the traditional descriptive geometry construction and presentation of Frontal, Horizontal and Profile Lines using the primary multiviews.

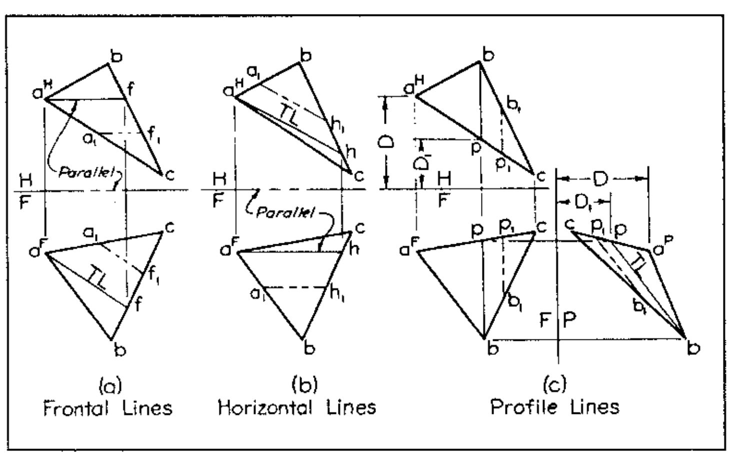

Figure 1. Principle Lines in a Plane

The concepts of lines in a plane, being either parallel or intersecting can also be demonstrated using a pictorial. Consider the problem of finding the boundary of an unlimited plane MNK that results from the intersection of the plane with the surfaces of the prism shown in the isometric pictorial of Figure 2a.

In this example, two basic principles are demonstrated. The first relates to the fact the "lines in a single plane must either intersect or be parallel." The second principle deals with the axiom that parallel horizontal, frontal or profile lines in a plane may be created by a series of horizontal, frontal or profile planes respectfully. More generally, "parallel lines in a plane are established by a series of parallel cutting planes." These principles relate to all orthographic views. They pertain equally to both oblique and isometric pictorials.

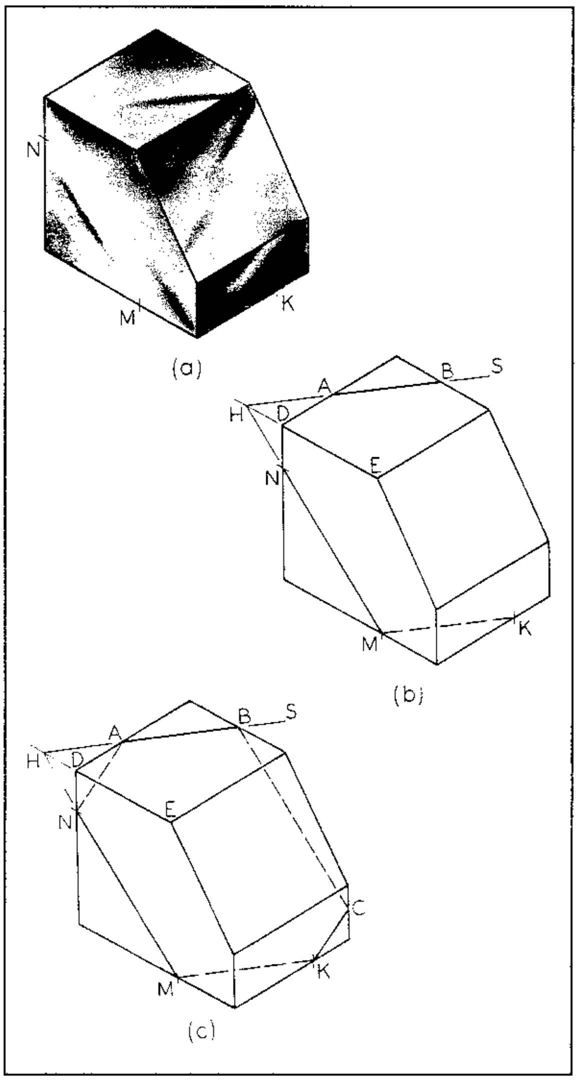

Figure 2 Pictorial Intersection

In Figure 2b the direct introduction of visible line MN and hidden line MK provides the initial required lines of intersection of plane MNK and the surfaces of the prism. Since the lines MN and DE both lie in the same frontal plane of the pictorial, they must either be parallel or intersect. When these two lines are extended, their intersection point H also lies in the upper horizontal plane of the pictorial. Horizontal line HS in the plane MNK may be added parallel to the horizontal line MK. By this procedure, visible line AB of the intersection boundary is obtained. Frontal line BC may then be introduced parallel to frontal line MN in Figure 2c. The introduction of parallel lines KC and NA complete the solution of the boundary of the plane and prism.

Piercing Points

Unless a line is in or parallel to a plane, it must intersect the plane. This intersection point is called the piercing point. The piercing point is the most important construction in descriptive geometry. The piercing point is the point common to the line and the plane. The two techniques of solving for piercing points using multiview projection

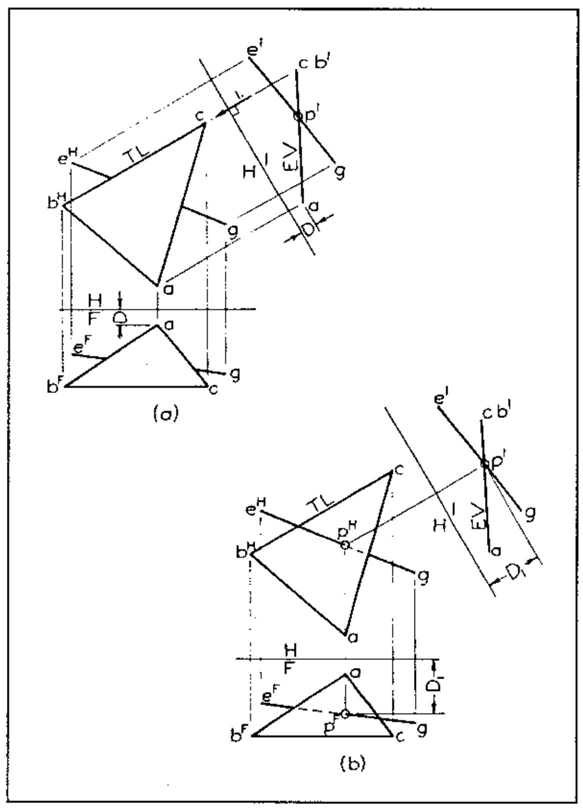

Figure 3. Piercing Point
Auxiliary-View Method

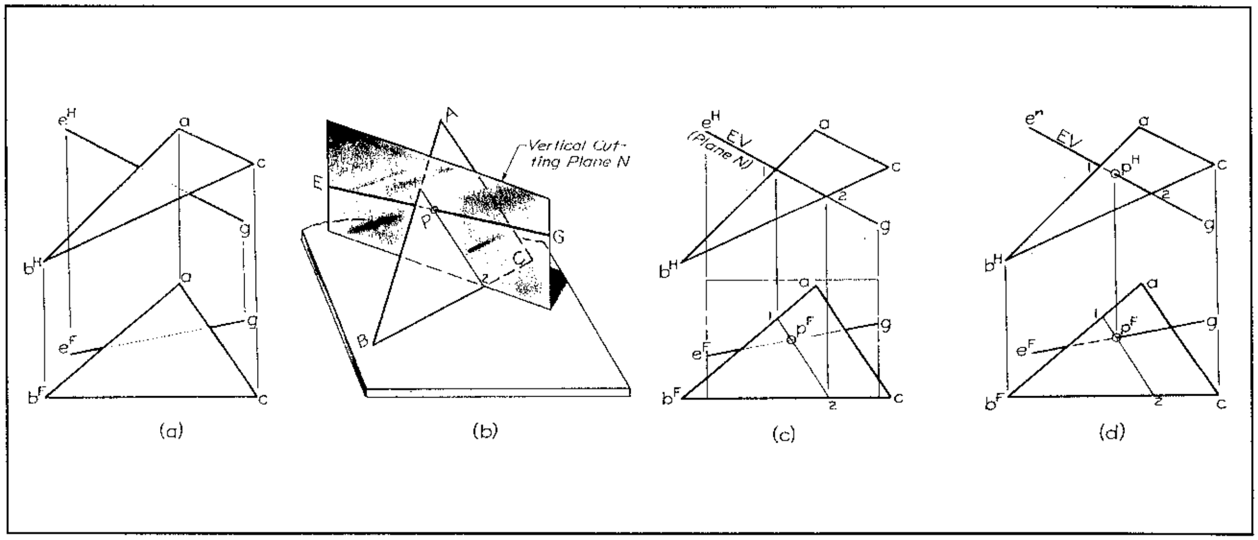

Figure 4. Piercing Point – Two-View Method

are the auxiliary view method shown in Figure 3 and the two-view method shown in Figure 4.

In Figure 5, the solution of the intersection of a line AB and a plane MNK using a pictorial requires a combination of the previous pictorial concepts and the use of a cutting plane similar to the two-view technique.

Since lines MN and AT both exist in the same plane P of the isometric pictorial outline, these lines must intersect or be parallel. They intersect in Figure 5b at point L. Point L is in the plane MNK and also in the top horizontal plane of the pictorial.

Next a vertical cutting plane ACBE is introduced containing line AB, in Figure 5c. Since lines AE and MN both lie in plane P, their intersection point 1 represents one point common to plane MNK and cutting plane ACBE. Similarly, since lines LK and AC both lie in the same upper horizontal plane of the pictorial, their crossing point 2 locates a second point common to plane ACBE. Now since lines 1-2 and AB lie in the same cutting plane, their crossing point O is their actual intersection point. But since line 1-2 also lies in plane MNK, point O provides the piercing point of line AB with the oblique plane MNK. A third point on the intersection line between MNK and ACBE can be found using the back frontal plane. This point is found where lines NK and CB intersect. This intersection point lies on the line 1-2 and confirms the result.

Visibility of line AB and plane MNK is determined by observation of the relative orientation of lines AB and MN in the pictorial at the apparent crossing point V.

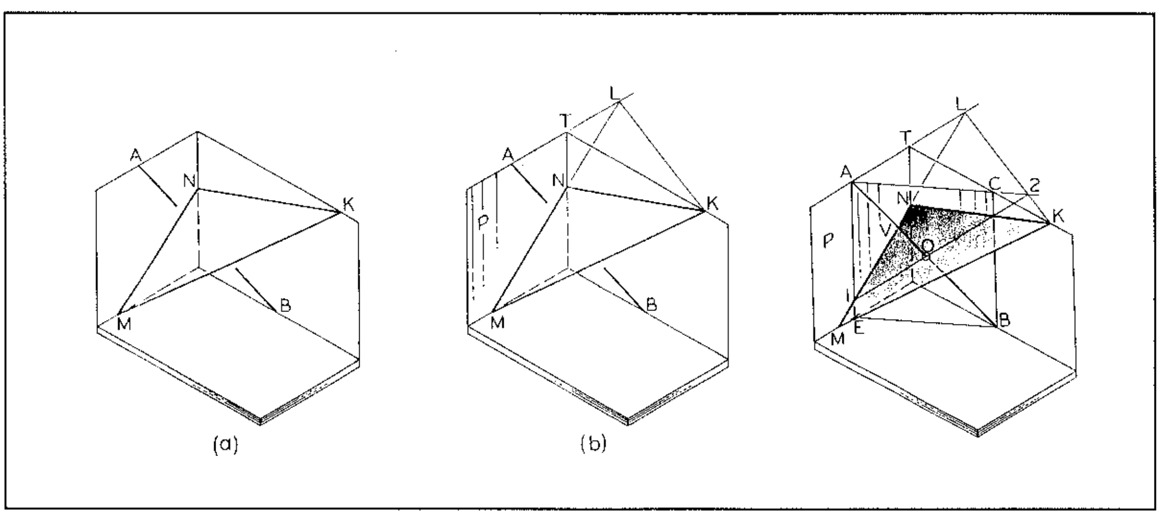

Figure 5. Pictorial Intersection of a Line and a Plane

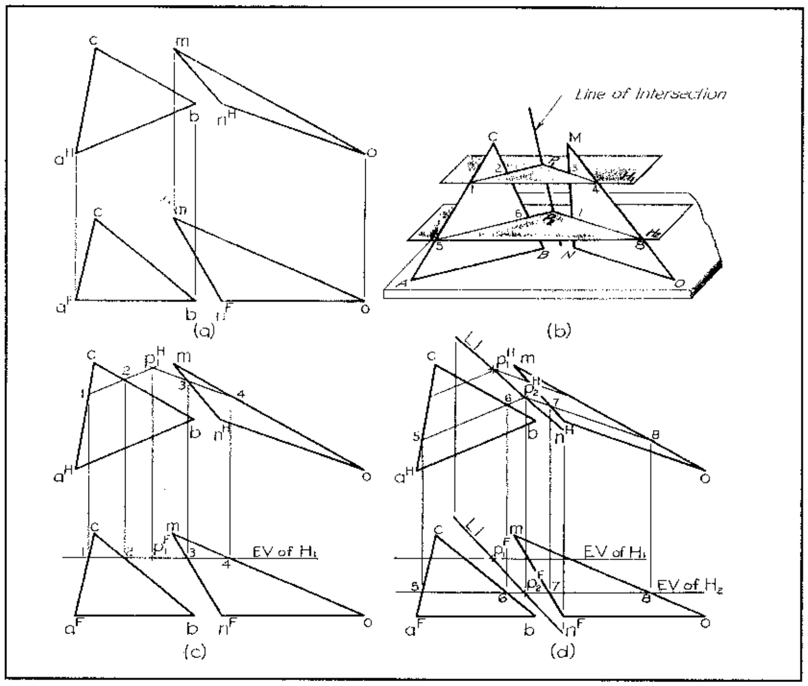

Figure 6.
Intersection of Two Planes
Cutting Plane Method

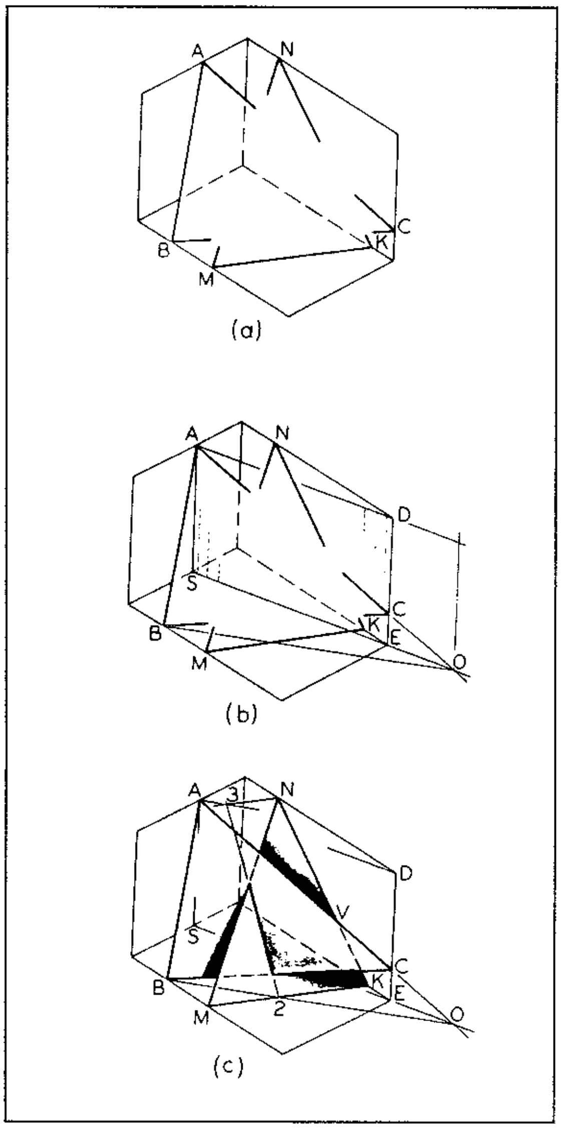

Figure 7. Pictorial Intersection of Planes

Intersection Of Planes

Any two planes must be parallel or they must intersect, even if the intersection falls beyond the limits of the planes as given. The intersection of two planes is the straight line common to the planes. Its position is determined, therefore, by any two or more points common to the planes. The three techniques of solving for intersections using multiview projection are the auxiliary view, two-view piercing point, and two-view cutting plane methods. The cutting plane method is shown in Figure 6.

A slight extension of the pictorial constructions previously introduced, together with the principles of intersections are involved in the solution of pictorial intersections. In the pictorial shown in Figure 7, the intersection of planes ABC and MNK and the related visibility are desired.

To obtain a horizontal line in plane ABC, a vertical cutting plane ADES, which contains line AC, is introduced in Figure 7b. Since AC and SE both lie in this cutting plane, these two lines extended intersect at point O. Since point O and point B both lie in the horizontal base plane of the pictorial, line BO represents a horizontal line of plane ABC.

Line BO of plane ABC and line MK of plane MNK each exist in the same horizontal base plane. They therefore intersect at point 2, which represents a point on the extended line of intersection of the two planes in Figure 7c. A second point on the line of intersection is obtained by the introduction of horizontal line N3 in plane MNK parallel to MK, and then a horizontal line A3 in plane ABC is added parallel to BO. These two lines exist in the same upper horizontal plane of the pictorial outline, and therefore crossing point 3 locates the desired second point on the extended line of intersection of the given oblique planes.

Line of intersection 2-3 is drawn as shown, with the bold portion of this line terminated at the limiting outlines of the given planes. Appropriate visibility of the intersecting planes may be established by a pictorial analysis of the relative location of lines AC and NK at position V.

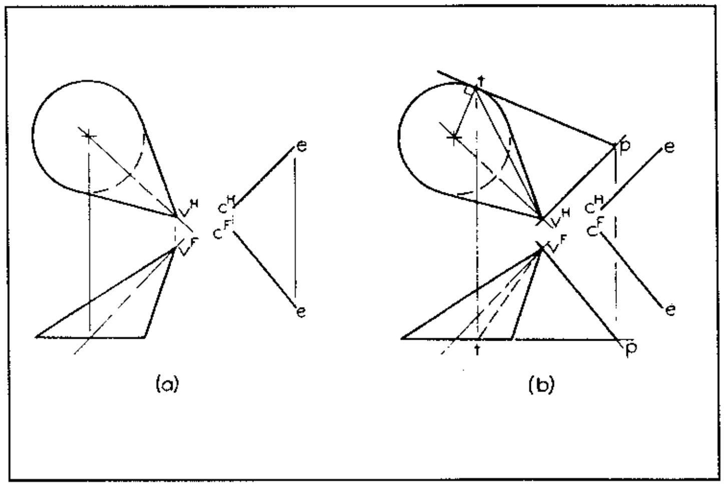

Figure 8. Plane Tangent to a Cone and Parallel to a Given Line

Plane Tangencies

A plane tangent to a regular curved surface, such as a cylinder or a cone, contains one and only one straight line element of the curved surface. Figures 8 demonstrates the multiview projection technique for finding a plane tangent to a cone and parallel to a given line not on the cone. Figure 9 demonstrates finding a plane tangent to a cylinder and containing a given point on the surface of the cylinder.

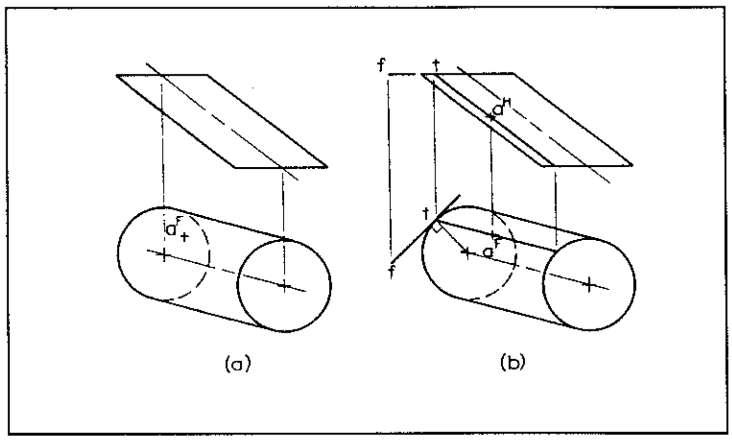

Figure 9. Plane Tangent to a Cylinder and Containing a Given Point on the Surface of the Cylinder

The concepts of tangencies, along with concepts of pictorial parallelism and pictorial intersections are combined to solve pictorial tangencies involving cones and cylinders.

For this example, a plane that is tangent to the cone and contains a point C outside the surface of the cone is to be established, Figure 10a. Since the desired tangent plane must contain the vertex of the cone as well as point C, line VC is drawn to contain these two points in Figure 10b. A second line intersecting line VC and also tangent to the circular base of the cone is needed next. It is critical that this second line exist in the circular base plane of the cone. With this fact in mind, line VC is extended to point P which lies in the same rear pictorial surface as does the circular base. Then line PT is added tangent to the circular base, providing the two intersecting lines VCP and PT that represent the specified tangent plane. Line VT

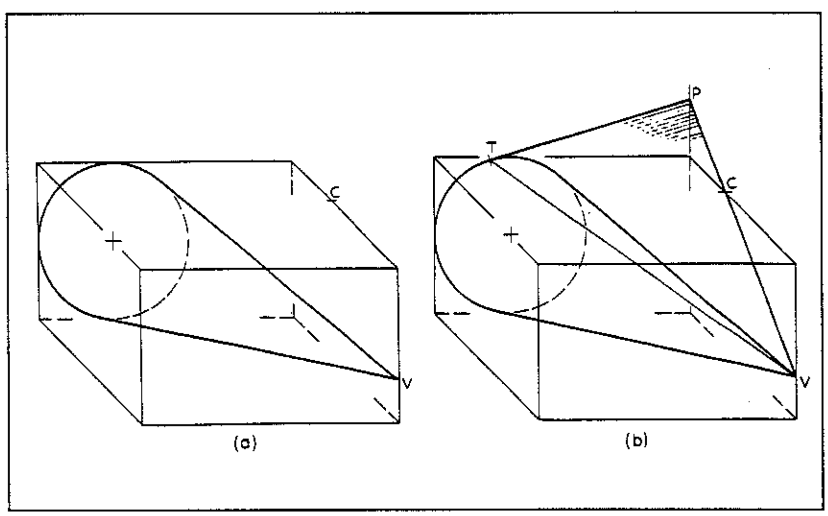

Figure 10. Pictorial Solution of Plane Tangent to a Cone and Containing a Point Outside the Cone

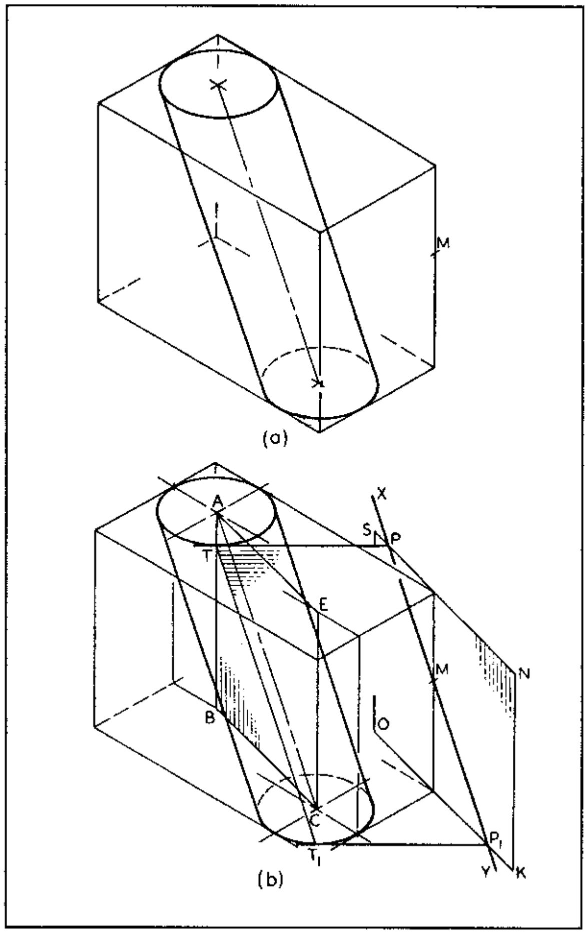

Figure 11. Pictorial Solution of a Plane Tangent to a Cylinder and Containing an Outside Point

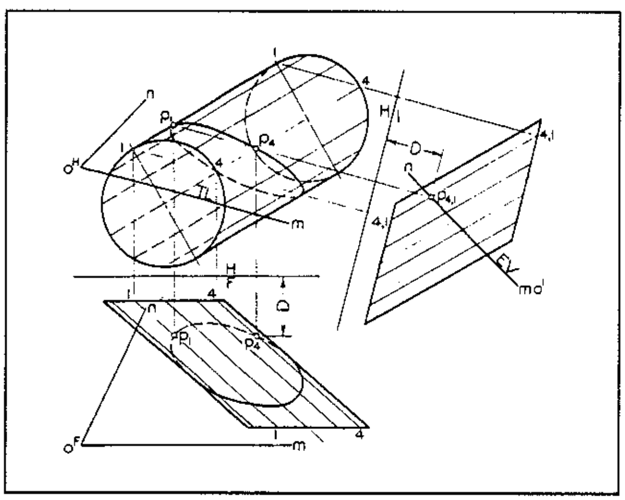

Figure 12. Intersection of a Plane and Cylinder Auxiliary-View Method

may be added to show the element of tangency.

For this example a plane is required that is tangent to the cylindrical surface and also contains a given point M, Figure 11a. This specified tangent plane must contain a line through point M that is parallel to center line AC of the cylinder. The initial construction requires the addition of a plane such as ABCE that includes center line AC, in figure llb. Line AE of this plane lies in the top surface of the pictorial and line BC lies in the lower surface. A plane parallel to plane ABCE is added to include point M. This plane consists of line SN parallel to line AE with both these lines existing in the top pictorial surface and line OK parallel to BC with these two lines existing in the lower surface. Line XY, which is parallel to the cylinder center line AC as well as all elements of the cylinder, is then added to plane SOKN.

Next the intersection of line XY with the base planes of the cylinder is needed. Since these bases lie in the top and bottom horizontal surfaces of the isometric frame, the intersection of line XY with horizontal lines SN and OK provides the pertinent piercing points P and P1. Lines PT and P1T1 are drawn tangent to the cylindrical bases to complete the presentation of the specified tangent planes. The tangent points T and T1 may be connected to represent the supplementary element of tangency.

Intersections of Planes with Solids

Finding the intersections of planes with solids or of two solids use the concepts previously developed with the intersection of planes. Figures 12 and 13 demonstrate these multiview projection concepts for a plane and a cylinder.

Previously introduced pictorial concepts are similarly applied to the intersection of a plane and cylinder problem. In Figure 14, the intersection of the cylinder and plane ABC is sought. In the solution shown, only two of at least ten or twelve necessary points on the curve of intersection are provided for illustration clarity.

An element MN of the cylinder is drawn; and containing this element a vertical cutting plane MRST is introduced. Next, a horizontal line CK of plane ABC is added parallel to the given horizontal line AB.

Since lines AB and MR both lie in the same upper horizontal plane of the pictorial outline, these lines intersect at point 2, a point on the line of intersection of planes ABC and MRST. A second point 3 on this line of intersection is at the intersection of CK and ST extended. Note that CK and ST both exist in the same horizontal base plane of the pictorial outline. Line of intersection 2-3 is then drawn.

Since element MN and line 2-3 each lie in cutting plane MRST, they intersect at point P, which establishes one of many needed points common to plane ABC and the surface of the given cylinder. Point Q is a second point established by the same cutting plane MRST. Additional cylinder elements and cutting planes are then added until an adequate number of points are secured to permit the representation of the curve of intersection as shown.

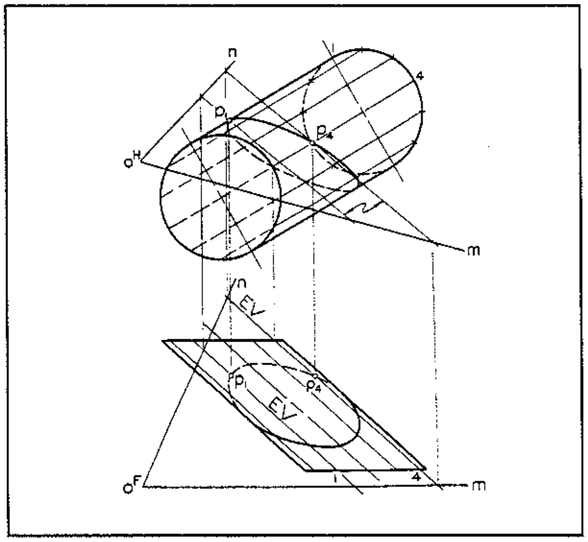

Figure 13. Intersection of a Plane and a Cylinder – Two-View Method

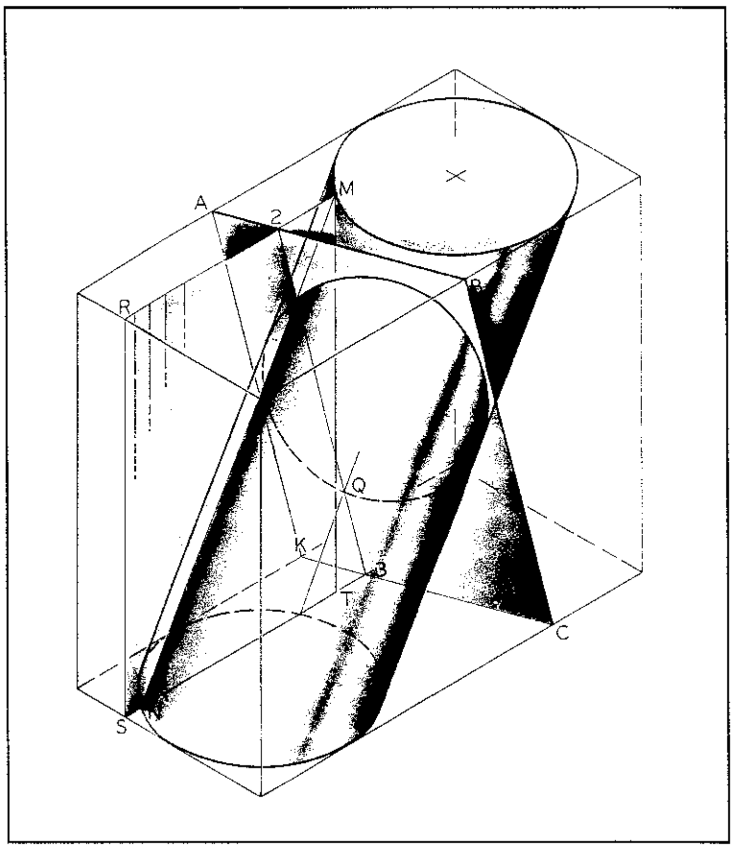

Figure 14. Pictorial Intersection

Conclusion

In this paper, pictorials have been used to demonstrate basic descriptive geometry problem solutions. The use of pictorials will help the student visualize and therefore understand the basic descriptive geometry concepts used to obtain these solutions. Therefore, the introduction of pictorial solutions will enhance any descriptive geometry course.

It is hoped this paper will encourage faculty to use these pictorial solution examples and to develop similar examples of their own.

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Impact of the Review Process on The Engineering Design Graphics Journal

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Abstract

A review process was introduced to the Engineering Design Graphics Journal (EDGJ) in 1986 with the publication of issue one, Volume 50. The first reviewed articles appeared in issue three of Volume 50. According to Jon Duff (1986), Editor of the Journal at that time, the purpose of incorporating the review process in the publication of technical papers was to "assure the kind of publication that best serves our Division and its members" (p. 4). An examination of the impact of the review process on the EDGJ was undertaken. The results tend to suggest that (a) adoption of the review process has, by one measure, improved the scholarliness of the Journal, and (b) there may exist a relationship between works published by the Journal since it adopted the review process and the makeup of the review board.

Introduction

The purpose of a review process is to ascertain a manuscript's quality and appropriateness for journal publication. These decisions are made by the journal's editor and are quite often facilitated by reviewers, who have been chosen by the editor for their expertise. From their input, the editor may accept a given manuscript, reject it, or ask the author(s) for revisions. Ultimately, these efforts are intended to make contributions to a discipline by publishing information that is "new, true, important, and comprehensible" (DeBakey, 1976, p. 3).

Purpose

The purpose of this study was to determine the impact of the review process on the *EDGJ*. Specifically, (a) has the review process had an impact on the scholarliness of the *Journal*, and (b) has the review process avoided the pitfalls of conservatism and elitism (O'Connor, 1978)?

Background

Journals, along with magazines, are a form of periodical, a serial normally thought of as being published more than once a year (Machlup & Leeson, 1978). Furthermore, there may be as many as four categories of journals: the (a) non-specialized, written for the intelligent and those who are well-informed on literature, art, social affairs, politics, etc.; (b) practical-professional, which are associated with applied fields, including technology, medicine, law, agriculture, management, etc.; (c) parochial, which target parochial audiences (local or regional); and (d) learned, which are normally associated with the pure sciences and other non-applied disciplines. Journals that fall into the latter category can be further classified as either primary-research or secondary-research journals, with the former being further classified by whether their articles are selected for coverage or not by major indexing and abstracting services.

Journals exist primarily to disseminate scholarly research on a somewhat regular basis, be it weekly, monthly, quarterly, or even on a somewhat irregular basis. Decisions regarding what is to be published rest with the editor. Frequently, the editor is supported by an editorial board, composed of specialists who are assigned selected responsibilities and relieve the editor of certain tasks. In addition, the editor may be assisted by experts, referees or reviewers, whose responsibility it is to advise the editor on the suitability of manuscripts for publication.

The Review Process

The role of the review process, also referred to as refereeing, is to maintain or raise the quality of the journal and the materials published by the journal (*National Enquiry*, 1979). Generally speaking, it is considered the most satisfactory of the alternative processes for pursuing excellence, even though it is frequently criticized for being slow and unfair.

Manuscripts are normally submitted to the editor of the journal. The editor, in turn, distributes copies to one or more reviewers. The reviewers judge the manuscript against a criterion established by the journal and submit their findings to the editor. On the basis of that input, the editor may choose to (a) reject it unconditionally, (b) accept it contingent upon mandatory revision, (c) accept it with suggestions for revision, or (d) accept it outright (DeBakey, 1976). Depending on the practices of the journal, manuscripts accepted contingent upon mandatory revision are usually treated like first-time submissions, and those accepted with suggestions for revision, once returned, are reviewed by the editor and sent on for publication.

Reviewers

Reviewers are usually chosen for their expertise or volunteer because of their interest in the review process and a felt need to contribute to the journal and discipline. The final decision, however, lies with the editor. Editors are encouraged to select reviewers who are willing and are able to provide sound advice and constructive criticism, and who are willing to give several hours for little, if any, remuneration (Bishop, 1984; DeBakey, 1976; O'Connor, 1978).

O'Connor (1978), however, has noted that one of the major criticisms with the review process is what is referred to as conservatism and elitism: forms of unfairness. While reviewers are chosen for their expertise, their expertise may make them partial to a particular paradigm, and results that appear in manuscripts may run contrary to their cherished beliefs. Furthermore, DeBakey (1976) has suggested that rather than allying themselves with the author to promote effective and accurate communication, there exists a tendency among some reviewers to censor or act as a hostile advocate. Thus, rather than giving the benefit of the doubt, manuscripts are rejected. Implicit in DeBakey's suggestion, too, is the likelihood that the ones receiving the benefit of the doubt are those whose findings are consistent with reviewer's cherished belief.

Assessing Scholarliness

Assessing the impact of adopting the review process in the publication of a journal is by no means a simple task. There are qualitative measures of journal quality, and there are means by which one can quantify journal quality.

"The purpose of a review process is to ascertain a manuscript's quality and appropriateness for journal publication."

Citations

Reputable researchers who use the works of others during the course of conducting research and in the preparation of scholarly papers usually cite those works in references lists. While the reasons given for this practice are numerous, the bottom line is that it is a scholarly convention by which researchers abide. Minimally, these lists provide readers with the sources of information used by author(s) in conducting their research and in the preparation of papers, and enable readers to retrieve those sources. More importantly, the practice of citing the works of others suggests that certain relationships exist between researchers and the discipline's literature. Ziman (1969) has suggested that:

> Scientific papers are derivative, and very largely unoriginal, because they lean heavily on previous research. The evidence for this is plain to see, in the long list of citations that must always be published with every new contribution. These citations not only vouch for the authority and relevance of the statements that they are called upon to support; they embed the whole work in a context of previous achievements and current aspirations. It is very rare to find a reputable paper that contains no references to other research. Indeed, one relies on the citations to show its place in the whole scientific structure just as one relies on a man's kinship affiliation to show his place in his tribe. (p. 318)

Implicit in this relationship is the frequently made assumption that works cited are by some measure more important than those not cited. That is, by examining references lists, one can identify the more important scholars, publications, articles, etc. in a given discipline (Nicholas & Ritchie, 1978). Furthermore, while there are inherent weaknesses in the use of citation counts to assess the quality of a journal, citation counts nevertheless can provide a limited measure of its scholarliness (Nicholas & Ritchie, 1978).

Engineering Design Graphics Journal

The *EDGJ* is the official publication of the Engineering Design Graphics Division of the American Society for Engineering Education. While there are other publications that disseminate discipline related information, the *EDGJ* is the principle medium of formal communication in English for engineering design graphics professionals. For the most part, the purpose of the *EDGJ* has been to:

> (1) encourage research, development, and refinement of theory and application of engineering design graphics for understanding and practice, (2) encourage teachers of engineering design graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses, and (3) stimulate the preparation of articles and papers on topics of interest to the membership (Sadowski, 1993, p. 2).

The first issue of the *EDGJ* (volume 1, number 1) appeared in 1936 as the *Journal of Engineering Drawing*. In 1958, the name was changed to the *Journal of Engineering Graphics* with the publication of volume 22, number 2. The current name for the *Journal* has been in use since 1970 with the publication of volume 34, number 1.

The review process was introduced to the *EDGJ* in 1986 with the publication of issue one, Volume 50. The first reviewed articles appeared later that year in issue three of Volume 50.

Methodology

Impact of the review process on the *Engineering Design Graphics Journal* was facilitated by an analysis of feature articles published in the *Journal* and the makeup of the Review Board. For the purpose of this study, the following parameters served to define the term *feature article*:

1. Articles that appeared to be first-hand accounts and could have been prepared and read at conferences or meetings. Furthermore, they may be characterized as (a) representing research not previously published, (b) having been reviewed by peers before being accepted or rejected for publication, and (c) being retrievable for future use (American Psychological Association, 1983).

2. Articles which were not news reports of various issues and activities and news summaries of meetings, committees, panel discussions, discussion groups, symposia, conferences and the like; reports of statistical data; or reports of related professional associations and committees (Schrader, 1985).

Data Collection

Data germane to the study were compiled with the aid of Microsoft Excel (Microsoft Corporation, 1987). One database included article data: volume number, issue number, year of publication, author name(s), author affiliation, and whether other sources of information were used in the preparation of the articles. A second, which dealt with the review board, included member names, member affiliations, and periods of service.

Results

Sixty-seven issues of the *EDGJ*, including an index issue, were published between 1970, when the first issue (volume 34, number 1) was published, and 1991, when the last issue (number 3) of the 55th volume was published. Four hundred thirty-three feature articles were published during this period. Eighty-one percent (n=349) of those articles were published prior to the publication of the first reviewed article. The balance (n=84) were published as reviewed articles (see Figure 1).

Of the 433 articles published, 46% (n=200) were accompanied by references lists or otherwise cited sources used by the authors in conducting their research or in preparing the articles. Sources were cited in 39.5% of the non reviewed articles (n=138), and slightly more than 73% of the reviewed articles (n=62) were accompanied by source citings (see Figure 1).

These data were subjected to a chi square test. The analysis disconfirmed the null of no difference with respect to the number of articles making references to other sources of information before and after the introduction of the review process. That is, there was a significant difference in the number of articles published which made references to other sources of information, before and after the introduction of the review process.

The data were also subjected to the Wald-Wolfowitz one-sample runs test for randomness specifically for trend effect. The null of a random sequence was disconfirmed. That is, the pattern of articles making references to other sources versus articles not making references to other sources was not random.

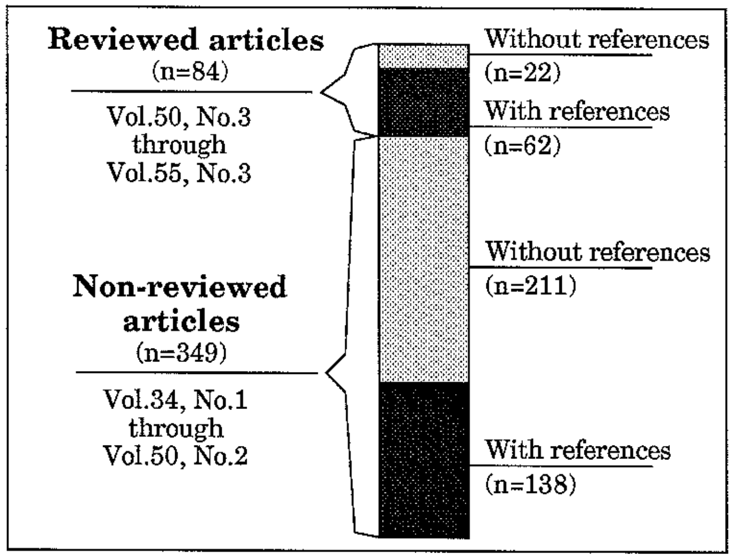


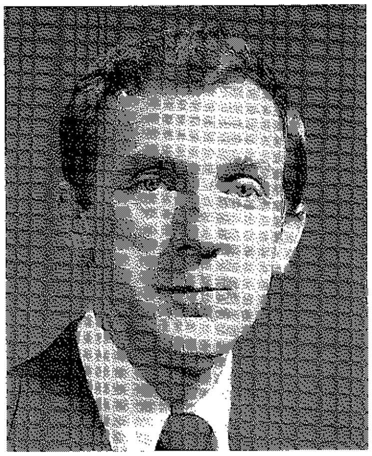
Figure 1. Proportion of articles published with and without references lists

Upon closer examination of the data, it was noted that a trend began to emerge in 1983 with volume 48. Published articles that were accompanied by references to other sources were becoming more the norm than the exception. The data for this period were also subjected to the Wald-Wolfowitz one-sample runs test for randomness, again for trend effect. The null of a random sequence for the period beginning with volume 48 and running through volume 55 was confirmed. That is, there was no relationship be-tween the magnitude of articles published which were accompanied by references to other sources and the review process during this period.

The feature articles published in the *EDGJ* were authored or co-authored by 332 different individuals. And while author affiliation was not always cited, the vast majority of the authors were affiliated with at least one of 162 different organizations. Most were either colleges or universities.

If volume 50, issue 3 can be used as a point of demarcation, it should be noted, then, that after the adoption of the review process, individuals from 24 different organizations continued to use the *Journal* as a means for disseminating information (see Figure 2). Individuals from 116 organizations who had used the *Journal* as a means of disseminating information, ceased to be represented following adoption of the review process. The remaining represents feature articles authored by individuals from 22

Division News and Notes



Chair's Message
J. Barry Crittenden

At the recent Mid-year Conference a presentation was made by Jane Beardsworth, representing the Foundation for Industrial Modernization (FIM). This organization, in conjunction with business, education, and labor organizations, has undertaken a thirty-month project under a grant from the U.S. Department of Education to a) develop skill standards for Computer Aided Design and Drafting (CADD) and b) develop a national, voluntary testing and certification program for individual CADD users. The project began in November, 1992 and the first 18-month phase is to be completed in April, 1994.

The skill standards under study by the foundation are listed on pages 45 and 46 of this issue of the *Journal*. As I studied the extensive lists, I questioned whether students at my university would be capable of meeting the proposed standards. We have had several discussions at VPI&SU on the extent of skills required and no doubt, if such a standard is established and followed, modifications will be necessary in our program of study. I encourage you to study these proposed skill standards and submit your comments to the *Journal* editor.

Communication within the Division should be improved by now. The 2nd edition of the Division Directory was mailed in January. Besides the mailing address, phone number, and fax number, the new directory includes the e-mail address of each Division member. Our thanks to Ed Boyer of The Ohio State University for producing this Directory as the Division proceeds to complete the early phases of its five-year plan.

A primary effort of the Division five-year plan is to increase membership. Under the direction of Mike Stewart (University of Arkansas - Little Rock) and Moustafa Moustafa (Old Dominion University), an *adopt a state* plan is being used. Each state in the union has a member of the Division to serve as membership liaison. These persons will be contacting universities and colleges in their *adopted* state to initiate communication between engineering design graphics instructors and our Division. It is critical that this membership drive be successful. Too few members will negatively affect the Division activities, especially the publication of the *EDG Journal*. **Help the Division** – use the form on page 46 of this issue of the *Journal* to submit names of prospective members to Moustafa Moustafa at Old Dominion University.

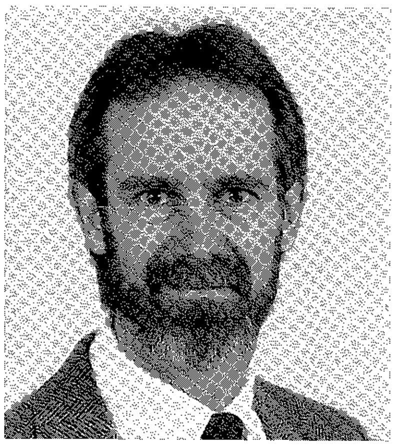
On October 31, the EDG, Division Executive Committee approved the location of the 50th EDGD Mid-year Conference. It will be in Ames, Iowa, and hosted by the Engineering Fundamentals and Multidisciplinary Design Division of the College of Engineering at Iowa State University. Rollie Jenison, General Chair of the Conference, has indicated that the conference will be held November 15 through 17, 1995. Frank Oppenheimer, long-time participant in EDGD activities and continuing supporter of the Division, has already called me asking for details. May I encourage each member of the Division to contact Division "senior citizens" who may be living in your region and encourage them to join us in Ames, Iowa, in November, 1995 for this historic Mid-year Conference. Let's strive to make this fiftieth anniversary Conference a reunion of past and present members as well as a technical meeting. Rollie is already planning special activities. In the meantime, don't forget the 49th Mid-year Conference to be held in Houston, Texas on January 12 and 13, 1995, hosted by the university of Houston and chaired by Ron Paré.

Nominees of Division Officers

The following have been nominated for the positions indicated.

EDGD Nominating Committee

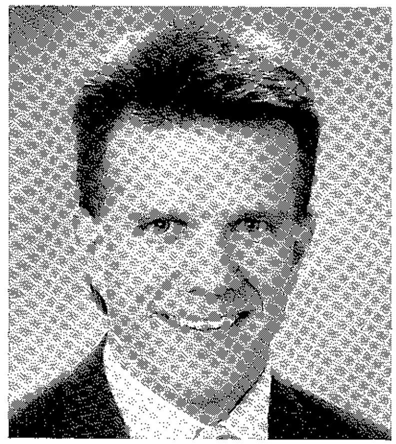
Secretary-Treasurer



James A. Leach

Jim is an assistant professor at the University of Louisville Speed Scientific School and Director of the Authorized AutoCAD Training Center. He holds the Bachelor of Industrial Design and Master of Education degrees from Auburn University. Before teaching at the University of Louisville, Jim worked as an industrial designer in Atlanta, Georgia for three years and then taught engineering graphics for 13 years at Auburn University.

As coordinator of Engineering Graphics at Auburn University, Jim is credited with developing the CAD labs and courses. As an ASEE/EDGD member since 1984, he has served as Director of Liaison Committees, member of the EDG Journal Board of Review, and Secretary/Treasurer. Other professional activities include several presentations, journal articles and workbooks.



Craig L. Miller

Craig is an assistant professor in the Department of Technical Graphics at Purdue University. He received his Ph.D. degree from The Ohio State University in 1992. Prior to joining the faculty at Purdue, he served three years as a Graduate Teaching Assistant in the Department of Engineering Graphics at The Ohio State University, two years as a Graduate Teaching Assistant in the College of Technology at Bowling Green State University, and high school and adult vocational teaching.

Craig has been an active member of ASEE and EDGD for five years. Currently, he is the advertising manager for the Engineering Design Graphics Journal. He has presented over fifteen papers at conferences in North America and Australia and has published in various journals. He was awarded the Oppenheimer Award for the best paper at the EDGD Mid-Year Meeting in 1991. His industrial experience includes curriculum development and computer-based training for Arthur Anderson & Co. and Nationwide Insurance.

Vice-Chair

Gary R. Bertoline

Gary is an associate professor in the Department of Technical Graphics at Purdue University. Prior to joining the faculty at Purdue, he served three years as a faculty member in the Department of Engineering Graphics at The Ohio State University and three years on the faculty of the Celina, Ohio branch of Wright State University. He has been a member of ASEE and EDGD for ten years.

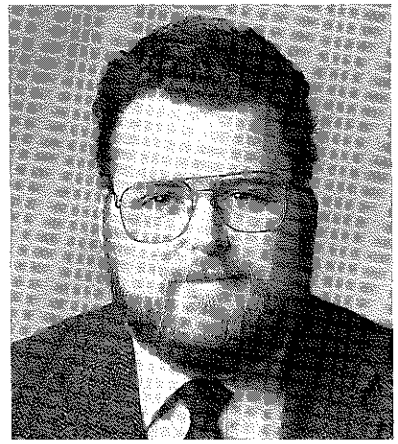
Gary is active in the ASEE, having served as treasurer and vice chair for the North Central Section. He served as chair of the Industrial Advisory Committee and is chair of the Technical and Professional Committee of the EDGD. He was program chair for the 1990 EDGD Mid-Year Meeting and has been awarded the Oppenheimer Award for the best paper at the EDGD Mid-Year Meeting three times. In 1990, Gary was named to the Steering Committee for the International Society for Geometry and Graphics.

Gary has presented over forty papers at professional conferences in North America, Australia, and Europe. He has authored numerous papers in journals and trade publications, as well as several books on engineering and technical graphics, CADD, and visualization research. His research interest is in measuring and improving visualization in engineering and technology students, and he is a member of the Purdue Engineering Graphics Research Project. Gary is the engineering and technical graphics series advisor for Irwin Publishing Company and serves on the Board of Review for *The Engineering Design Graphics Journal* and *Journal of Technical Graphics & Computing.*

Mary A. Jasper

Mary is an associate professor of Industrial Engineering at Mississippi State University. Her academic duties include the administration and coordination of all engineering graphics/ computer graphics courses taught both in the College of Engineering and as a service to other units within the university. She oversees a small but effective staff of three instructors and one assistant professor. Her second set of university duties involve the coordination of a state-wide Alliance for Minority Participation -- and NSF funded service/education program. In this capacity she is "Mahm" to almost two hundred minority students in science, engineering, and mathematics. She also runs a summer bridge program for minority students who will be attending college for the first time the following fall. She has served the EDGD as Director of Publications, member of the Freshman Design Competition committee, and more recently as one of the *EDGD Journal's* editorial staff. She is active in the Women's Engineering Program Advocate's Network (WEPAN), the American Association for the Advancement of Science (AAAS), the Mississippi Academy of Sciences, the Women In Science and Technology in Mississippi, and is a registered professional engineer in Mississippi. Last, but certainly not least, she is the mother of five children (including two female engineers) and the grandmother of one extremely active and precocious (of course) grandson.

Director of Publications



Mary A. Sadowski

Mary is a professor of Technical Graphics in the School of Technology at Purdue University. She has taught graphics at all levels of education, including elementary, secondary, and university classes. At Purdue her activities include teaching graphics, illustration, and desktop publishing.

Mary has been an active presenter at ASEE/EDGD and NSPI (National Society for Performance and Instruction) for the past nine years. She has written and presented especially in the area of creative thinking, problem solving, and desktop publishing.

Mary is currently the Director of Publication for EDG division, and has therefore been the editor of the *Engineering Design Graphics Journal* for the past two and a half years. She has enjoyed publishing the Journal and was pleased to be nominated to serve for another term.

Dennis R. Short

Dennis is an associate professor in the Department of Technical Graphics at Purdue University. He has been a member of EDGD/ASEE since 1987 and has been active in the division serving as advertising manager for the *Engineering Design Graphics Journal* 1990-1993 and helped significantly improve the financial health of the *EDGJ*. During the past 10 years Dennis has presented over thirty technical papers at conferences in engineering and education and published numerous conference proceedings and serial publications papers. He has also engaged in joint international publishing activities including a recent proceedings paper in Japanese. Dennis has been active in the international area having presented or published papers at 7 international conferences in the last 6 years and has been a session moderator at the last two ICECGDG conferences in Miami and Melbourne.

Dennis is currently engaged in supported research in the area of Computer Generated Immersive Environments (CGIE) and in basic educational research related to the cognitive aspects of graphics systems and of graphics education. He is also involved in research and development relating to teaching laboratories and instructional environments in graphics education. In 1991, Dennis was a fully funded visiting scholar to Fukuoka University in Kyushu, Japan and will be returning to Japan during the summer of 1994 as a fully funded visiting associate professor at Fukuoka University.

CALL FOR PAPERS

Engineering Design Graphics Division

1995 ASEE/EDGD 49th Annual Mid-year Meeting

University of Houston, Houston, Texas

January 12-13, 1995

Proposed Theme:

What's Graphics Got To Do With It?

Suggested Topics:

- Evolving graphics standards.
- The interaction of graphics and changing production procedures now and in the future.
- Electronic graphics - revolution or evolution?
- Are we losing the core of knowledge to learning the machine?
- Where is that "paperless" society?
- Effect of reduced military budgets on engineering and technology.
- Innovative teaching: catch phrase or fact?
- Technical graphics is more than engineering.
- Unusual applications for graphics.
- What is in the near or far future for graphics?
- Co-operation between industry and education, both good or bad experiences.
- Graphics curriculum issues.
- Graphic Science: Fact or Fiction?

Send a one-page maximum, double-spaced abstract by **June 15, 1994** to:

Charles W. White
Department of Technical Graphics
1419 Knoy Hall of Technology
Purdue University
West Lafayette, IN 47907-1419

Phone: 317-494-8738
Fax: 317-494-0486
E-mail: cwwhite@vm.cc.purdue.edu

Logo Contest

In two years the Engineering Design Graphics Division will host the 50th Annual Mid-Year Conference and we would like to celebrate this occasion with a new EDGD logo. The executive committee of the Engineering Design Graphics Division invites you and your students to submit new logo designs that would take the division into its second fifty years.

AWARDS

FIRST PLACE

AutoCAD Release 12 for DOS or Windows
plus AutoVision for DOS or Windows

SECOND PLACE

3D Studio Release 3 for DOS

THIRD PLACE

AutoSketch Release 2 for Windows

- The new logo must take the division into the 21st century.
- It must be in black and white.
- It must reproduce effectively at very small and possibly large scales.

Submit your design:

1. Black and white only.
2. Camera-ready artwork should be submitted on 8.5" x 11" board.
3. It must be received no later than **May 15, 1994**.
4. Put designer's name, address and phone number on the back.

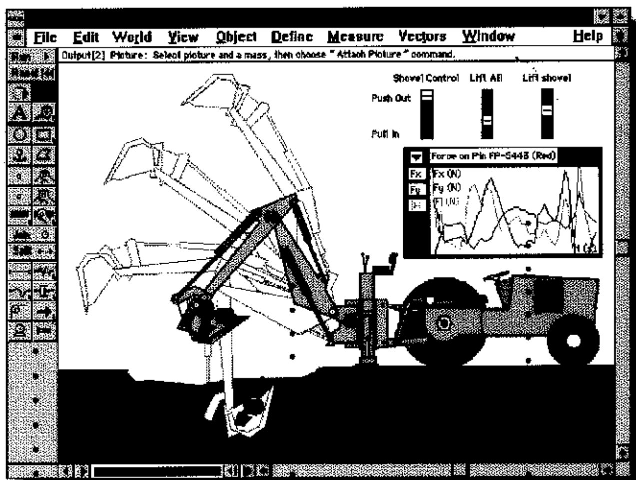
- Judging will be done by an independent group of graphics designers.
- Winners will be announced at the Engineering Design Graphics Banquet at the ASEE annual conference in Edmonton, Canada on June 28, 1994.
- All submissions become property of the Engineering Design Graphics Division, and will not be returned.

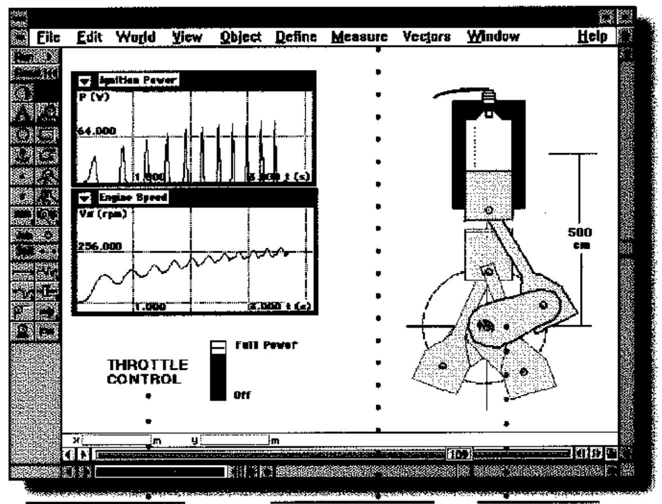
Current EDG logo

Submit artwork to:
Mary A. Sadowski
Engineering Design Graphics Journal
Technical Graphics
1419 Knoy Hall
Purdue University
West Lafayette, IN 47907-1419

Phone: 317-494-8206
Email: sadowski@vm.cc.purdue.edu

Destroy your only prototype, overload your latest design, and see what 30,000 pounds of force does to a pin joint. And that's __before__ lunch.





Quickly construct simulations with our Smart Editor, tool palette, and objects like springs, joints, actuators, dampeners...

Working Model automatically handles collisions, contacts & frictions for realistic simulations.

Analyze your simulation data with on-screen graphs, tables and charts.

Quickly modify simulation parameters — or part of your design — and run your simulation again.

Working Model's powerful scripting language stays hidden until you need it — but it lets you model even non-linear systems.

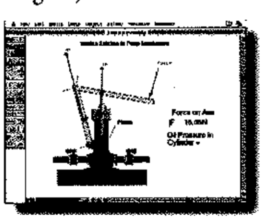
Import designs from most popular CAD programs.

Powerful dynamics simulation software for your desktop computer.

Now you can simulate, test, analyze and refine even highly-complex mechanical systems — right on your Windows or Macintosh computer.

With Working Model.

It marries a powerful dynamics simulation engine to an elegant, intuitive interface. So you can quickly simulate even elaborate systems, and analyze the results right on your desktop.



Simulate destructive tests or prototype and refine your latest designs. Working Model helps you analyze your data right on-screen — or lets you export it for later analysis.

Our Smart Editor, tool palette and help ribbon make it easy to assemble physically accurate models. You can even import designs from popular CAD programs.

Once they're assembled, your designs spring to life — in simulations operating according to physical laws.

You control the parameters of your simulation and all the objects in it. So you can quickly alter properties like mass or friction, or modify an actuator arm or joint... and then re-run your simulation right away.

Call for a demo disk – or ask about our volume discounts and site licenses.

You can analyze your simulation data with on-screen charts, graphs or tables — or export data for later analysis.

Working Model also features a powerful scripting language that stays hidden until you need it — but it lets you create highly accurate, non-linear simulations... like the force on a piston during combustion.

So you become more productive. And get full-time access to powerful dynamic simulations right on your desktop — access that you might not have had before.

Yet, despite its power, Working Model costs only $995 — far less than high-end workstation software.

Call **1-800-766-6615** for a demo disk or more information. And start refining your most-complex mechanical designs. Right on your desktop.

Knowledge Revolution

PRODUCT REVIEW ... Working model

For the Macintosh...
...by Michael G. Gabel

Working Model by Knowledge Revolution is a physical based modeling package allowing the user to build simple or complex systems and simulate their behavior under a variety of constraints and forces. The simulation engine of Working Model calculates the motion of interacting bodies using Newtonian mechanics to provide a professional tool for engineering and animation simulation. In addition to user imposed constraints such as pulleys, joints, and springs the simulation engine deals with real world interaction such as collisions, gravity and electrostatics.

Anyone familiar with the Macintosh interface will feel right at home with Working Model. The core of the user interface is the Smart Editor which keeps track of connections and constraints among objects as they are constructed. To build a mechanism, the user draws components and indicates where and how the pieces should be joined. The mechanism can be rotated and moved while maintaining the fundamental integrity of the components and the joints between them.

Working Model also supports inter-application communication using Apple events to communicate with other applications during a simulation. For instance, a Microsoft Excel spreadsheet can be used to model an external control system. Data can be passed to a spreadsheet, results calculated, and the results returned to Working Model, all while a simulation is in progress. Complex functions, such as table lookup, can be implemented in a spreadsheet and then linked to a Working Model simulation.

Working Model imports and exports data to most popular CAD programs through the DXF file format. Also supported are the standard PICT, Meter Data, and QuickTime movie formats. Animated data can be exported in a variety of formats. Because of the accuracy with which it models, complex interaction of moving objects, Working Model is a natural tool for creating animated images of unprecedented realism.

Working Model is an industrial strength simulation package that deserves a hard look by anyone interested in accurate simulations or animations.

For Windows...
... by Jon M. Duff

Working Model (WM) is a two-dimensional graphical simulation engine capable of modeling most of the physical and mechanical conditions of the real world—at least enough of them to make the product extremely useful. The process is fundamentally simple: draw and position objects, establish constraints, assign mass properties, create meters or monitors that display graphical or numeric data, and run the experiment. In practice, however, very little can be done without a good basic understanding of physics and mechanics, and a generous dose of creativity to do something productively with this tool.

What You Can Do in Working Model

Working Model fits the developing model first and draw later paradigm. It is the electronic version of cardboard prototypes with the benefit of being able to extract technical information or to make the model perform as desired by importing data into the experiment. You can model real-world phenomenon to understand the underlying dynamics or use WM to model hypothetical designs in order to make early design decisions.

What You Can Do with Working Model

Experiments in WM can be exported in DXF format for a variety of purposes and WM graphics can be copied to the clipboard and pasted into other WINDOWS applications. The DXF format is fine for porting WM geometry to CAD for detailing, and the level of precision is more than adequate for beginning detail documentation. Sophisticated animation engines like Wavefront and 3D Studio will import WM geometry. However, WM's forte' is simulation, not animation. It might be better to use only the basics of WM geometry rather that expect pictures out of this simulation engine.

Use in Engineering and Technology Education

The possibilities for WM in the technical classroom are limited only by our preconceived ideas about learning and instruction.

The concept that students come to our classes to learn, that we are the sources of all knowledge, that we control the equipment and the software—and thereby the learning—is antiquated and passé. The technical world is WM 's textbook. Working Model is simply a tool for first understanding how the world works, and then as technical expertise increases, a way of shaping the world to desired outcomes. The charge to technical educators using a program such as WM would be to abstract real-world systems so that the underlying physics and mechanics can be understood by students.

Working Model is not a perfect tool. It runs marginally on a 486 DX2/50 and the overhead of WINDOWS requires 8mb of memory. You can't create 3D models directly. You have limited export filters. Every graphic program for WINDOWS should include WMF, CGM, and EPS export options. Period. You would expect WM graphics to appear in proposals and studies, something limited by having only a DXF export filter. But still, WM allows you to do things on the desktop that a few years ago were impossible.

CALENDAR

49th Annual Engineering Design Graphics Mid Year Meeting
January 12-13, 1995
Houston, TX
Host: University of Houston
General Chair: Ron Paré
Program Chair: C. Wayne White
Theme: What's graphics got to do with it?
For more information:
See page 34 of this issue

50th Annual Engineering Design Graphics Mid Year Meeting
November 15-17, 1995
Ames, Iowa
Host: Iowa State University
General Chair: Rollie Jenison

1994 ASEE Annual Conference & Exposition
Joint conference with the Canadian Conference on Engineering Education
June 26-29, 1994
Edmonton, Alberta, Canada
For more information:
1818 St., N. W., Suite 600
Washington, D. C. 20036
Phone: 202-331-3523
Fax: 202-265-8504

The Fourth International Conference On Cad & Cg
October 22-25, 1994
Wuhan, P. R. China
For further information:
Professor Cheng Gang Li
Department of Mechanical Engineering I
Huazhong University of Science and Technology Wuhan, 430074 P. R. China
Tel: China 027 (Wuhan)-701881
Fax: China 027 (Wuhan)-700063

ASEE 1994 North Central Section Annual Conference
April 7-8, 1994
Host: Grand State University
For more information:
Paul Plotkowski
School of Engineering
Grand Valley State University
301 West Fulton Street
Grand Rapids, MI 49504
Phone: 616-771-6750
Fax: 616-771-6642

Teaching Electronic Publishing
Darmstadt, Germany
April 12-13, 1994
For more information:
Mary Dyson, TEP94 workshop
Department of Typography & Graphic Communication
University of Reading
2 Earley Gate
Whiteknights
Reading, RG6 2AU, UK
Tel: 0734 318084 Fax: 0734 351680
e-mail: ltsdyson@uk.ac.rdg

Fourth Eurographics Workshop on Object-Oriented Graphics
Sintra, Portugal, May 9-11, 1994
For further information:
Peter Wisskirchen, GMD-FIT,
Postfach 53731-1316
D-53757 St. Augustin 1, Germany
email: wisskirchen@gmd.de.
Tel: +49-2241-142315
Fax: +49-14-2241-2065

Feature Modeling And Recognition In Advanced Cad/cam Systems
Valenciennes, France, May 24-26, 1994
Lamih-university Of Valenciennes
For more information:
Dominique Deneux
LAMIH - University of Valenciennes
Le Mont Houy - BP 311
59304 Valenciennes Cedex, France
Phone : (+33) 27 14 13 55
Fax : (+33) 27 14 12 88
E-Mail: deneux@univ-valenciennes.fr

Computer Animation '94
Geneva, Switzerland
May 25-27, 1994
For further information:
Professor Nadia Magnenat Thalmann
MIRALab, CUI
24 rue du General-Dufour
CH-1211 Geneva 4, Switzerland
tel: +41-22-705-7769 fax: +41-22-320-2927
Email: thalmann@uni2a.unige.ch

Fractals in Engineering '94
June 1-4, 1994
Ecole Polytechnique de Montreal Montreal, Quebec, Canada
For more information:
SECRETARIAL OFFICE
Fractals in Engineering '94
Applied Mathematics Department
Ecole Polytechnique
P.O. Box 6079 - Station A
Montreal (Quebec) - Canada H3C 3A7
phone: (514) 340-5968 fax: (514) 340-4463
e-mail: conference@mathappl.polymtl.ca

ED - MEDIA '94
World Conference on Educational Multimedia and Hypermedia
June 25-29, 1994
Vancouver, Canada
For further information:
Ivan Tomek c/o AACE
P.O. Box 2966
Charlottesville, VA 22902 USA
E-mail: AACE@virginia.edu
Phone: 804-973-3987; Fax: 804-978-7449

IEEE TENCON '94
22-26 August 1994,
SINGAPORE Special Session On COMPUTER GRAPHICS & APPLICATIONS
For more information:
Dr. Murali Damodaran
Centre for Graphics & Imaging Technology
Nanyang Technological University
Nanyang Avenue, SINGAPORE 2263
Tel: (65)-799-5599,
Fax: (65)-792-4117
E-mail: mmurali@ntu.ac.sg

HCI '94
People And Computers
University Of Glasgow
August 23 - 26, 1994
For more information:
HCI '94 Conference
Ms. Elizabeth Gray
External Educational Services
University of Glasgow
G12 8QQ, UK
E-Mail: HCI94@dcs.glasgow.ac.uk
Tel: +44 (0)41 330 4266
Fax: +44 (0)41 330 4035

EDGD Summer

Dear EDGD Members:

Early this fall, I mailed a survey instrument to the EDG Division membership. I requested a response by October 22, 1993, so that I could compile the results and present them to the executive committee and to the membership at the Mid-Year meeting in Athens, Ohio. This objective was realized, and, as a result of the discussions that followed, I was asked to present the results to the membership at large through the Engineering Design Graphics Journal.

First of all, the executive committee decided that more work was needed before the Division committed itself to scheduling a summer school. Therefore, the tentative date of summer, 1995, at the Anaheim conference was abandoned. My thanks to all who responded to the survey are appropriate, for much useful information was obtained.

It is especially gratifying that 18 of you were will to help plan a summer school, 17 were willing to conduct classes or labs, and 14 of you were willing to develop materials for such a school. I think that this speaks strongly about the level of support provided by the membership to the development of a viable five-year plan.

However, the executive committee found several things about the response somewhat disappointing. Only 58 members responded, out of a mailing of about 400. About one-half of those who did respond indicated interest in attending the school as participants. Many reasons could explain this result, but we just don't know at this point if the idea of a summer school is practical. Another area of concern is the lack of agreement on a unifying theme.

I will be calling upon those of you who volunteered to help plan the school for your ideas on how to proceed. More importantly, some kind of response from those of you who have been silent on the issue until now is really essential. Please call, write, fax, or E-mail me or any executive committee member with your views and opinions. There are many positive benefits the Division could realize from a successful summer school, but this project cannot be successful without your help.

Del Bowers
EDGD Director of Programs
Colorado School of Mines
1500 Illinois Street
Golden, CO 80401-1887

Phone: 303-273-3960
Fax: 303-273-3602
e-mail: dbowers@mines.colorado.edu

EDGD SUMMER SCHOOL

All of you who are EDGD members should have received a survey from Del Bowers about the possibility of establishing a Division Summer School, perhaps in conjunction with the 1995 ASEE Annual Conference in Anaheim, CA. From the 500 surveys mailed, Del received only 58 responses. These responses were generally positive, with many of those responding, offering to help plan, however, the division cannot make plans based on 58 responses. If you have not returned your survey to Del, please take the time to do so now, or at least write to him about your thoughts concerning this venture. We need to hear from you.

1. I will support the development and conduct of an EDGD summer school by:

a. Attending as a participant.
b Serving on a planning committee.
c. Developing course materials.
d. Serving as a trainer or facilitator, if needed.
e. Raising money.
f. I can help by
g. I support it but can't promise any of the above.
h. I can't support it at this time (if answer is g., please feel free to offer any written reasons or opinions. Also if you are able to assist, I would appreciate the inclusion of your name in this response.)

2. I would prefer the EDGD Summer School be scheduled:

a. In the 2-4 days immediately (before, after) the ASEE Annual Conference in 1995 (Anaheim).
b. Some other time not associated with the annual conference.
c. Electronically, thus precluding a conference.
d. Not in 1995; it is too soon.

3. The theme of the conference should be:

a. EDG education for the 90's.
b. Industrial practices for EDG in the 90's
c. EDG in an integrated design curriculum.
d. The state of the art in CAD, CADD, Solid Modeling, Rendering, Animation, and engineering visualization hardware and software.
e. Multimedia technology for labs, CAE.
f. Development of practical materials and guides to integrate into existing courses.
g. My idea of a theme:

____

4. The format of the Summer School should be:

a. Short courses composed of 2-4 hour segments (course may consist of two or more segments); lecture format.
b. Short courses, mostly hands-on labs.
c. Team-oriented solutions of assigned tasks with presentation to group.
d. Seminar/round table panel discussions with audience interaction.
e. Work session (before, after, both) Summer School meeting with material mailed (hardcopy, electronically) to participants, plus face-to-face interaction with trainers/facilitators at 2-4 hour segments during School.
f. Total electronic interaction (E-Mail) for group development of project without physical face-to-face Summer School.
g. Some combination of the above, especially (letters)__________
h. Can't say without knowing content, but I lean toward (letters)__________.
i. Another format I would favor (in addition to, in place of) the above is

____

5. The Division should plan to:

a. Make money on the School, i.e., fees should exceed costs.
b. Break even on the school.
c. Support the school to a dollar limit of $__________. Funds to be raised by (activity)

____

d. Seek industry/vendor support for the School (full, partial).
e. Seek NSF, or other foundation grants to support school.

6. I would be willing to pay conference registration fees in the range of:

a. $750-$1000. b. $500-$750.
c. $250-$500. d. $100-250.

7. Please feel free to append any comments or suggestion you wish.

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The Equilateral Triangle–Another Look

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Emeritus Professor Clarence Hall's article, "The Equilateral Triangle," published in the Autumn issue of The *Engineering Design Graphics Journal*, presents the unique geometric relationship of an angle (θ) with triple angle (3θ). My purpose in this article is to provide an alternate solution which proves Equation 10 by a combination of trigonometric functions and geometry and also proves the relationship between Equation 10 and 2.

As shown in Fig. 1, taken from Hall's article, an equilateral triangle ABC is given in which sides = S, and medians AD, BE, and CF. With point D as center and radius DB, construct the circle BFECG intersecting median AD at H, and G. Choose an arbitrary point K on arc HE and draw lines KB and KC intersecting median CF at M and median BE at N. Label angles MCK and MBF as θ, and angles KCE and MBN as ß.

$$(\theta + \beta) = 30^\circ, \text{ or } \beta = (30^\circ - \theta), \text{ and } CBK = (60^\circ - \theta)$$

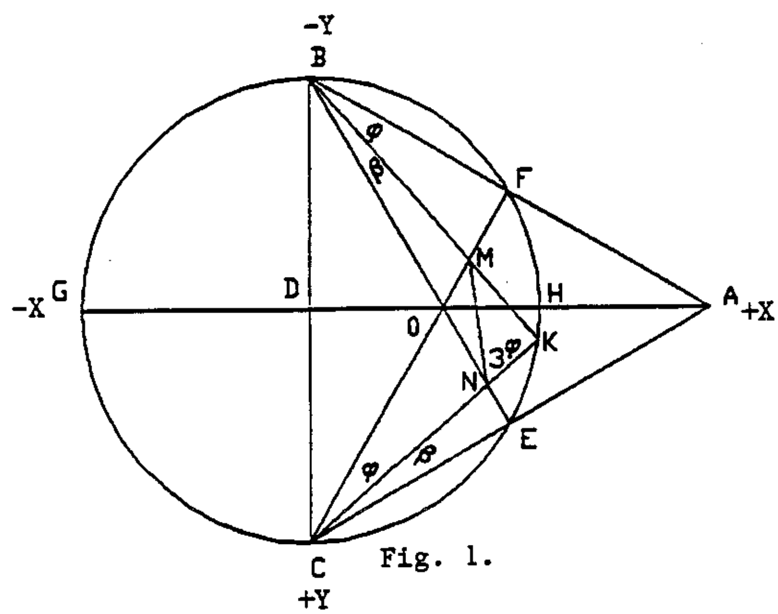

Fig. 1.

Equation 10 in Hall's article states the following relationship:

$$\text{Tan}(3\theta) = \frac{\text{Sin}(\theta)\ \text{Sin}(60^\circ - \theta)\ \text{Sin}(60^\circ + \theta)}{\text{Cos}(\theta)\ \text{Cos}(60 - \theta)\ \text{Cos}(60 + \theta)}$$

Reference

Hall, C. E. (1993). The Equilateral Triangle. *The Engineering Design Graphics Journal*, 57, (3), 38-42.

To prove the above function, we simplify the equation as follows:

$$\mathrm{Tan}(3\theta) = \mathrm{Tan}\theta \ \mathrm{Tan}(60^\circ-\theta) \ \mathrm{Tan}(60^\circ+\theta)$$

From triangle MCK, $\mathrm{Tan}\theta = MK/CK$

And from triangle CBK, $\mathrm{Tan}\angle CBK = \mathrm{Tan}(60^\circ-\theta) = CK/BK$

$$\mathrm{Tan}(60^\circ+\theta) = \mathrm{Tan}[90^\circ-(30^\circ-\theta)] = \mathrm{Cot}(30^\circ-\theta) = \mathrm{Cot}\,\beta$$

From triangle EBK, $\mathrm{Cot}\beta = BK/NK$

Thus, $\mathrm{Tan}(3\theta) = \mathrm{Tan}\theta \ \mathrm{Tan}(60^\circ+\theta) \ \mathrm{Tan}(60^\circ-\theta)$

$$= \frac{MK \cdot CK \cdot BK}{CK \cdot BK \cdot NK} = \frac{MK}{NK}$$

From triangle MNK, $MK/NK = \mathrm{Tan}(3\theta)$, therefore, Hall's Eq. 10 is proved.

To prove Hall's Eq. 10 to be the same as Eq. 2, we use the tangent double-angle formula:

$$\mathrm{Tan}(3\theta) = \mathrm{Tan}(2\theta+\theta) = \frac{\mathrm{Tan}2\theta + \mathrm{Tan}\theta}{1 - \mathrm{Tan}2\theta \ \mathrm{Tan}\theta} = \frac{\dfrac{2\mathrm{Tan}\theta}{1-\mathrm{Tan}^2\theta} + \mathrm{Tan}\theta}{1 - \dfrac{2\mathrm{Tan}\theta}{1-\mathrm{Tan}^2\theta}\cdot\mathrm{Tan}\theta}$$

$$= \frac{2\mathrm{Tan}\theta + \mathrm{Tan}\theta - \mathrm{Tan}^3\theta}{1 - \mathrm{Tan}^2\theta - 2\mathrm{Tan}^2\theta} = \frac{3\mathrm{Tan}\theta - \mathrm{Tan}^3\theta}{1 - 3\mathrm{Tan}^2\theta}$$

$$= \frac{\mathrm{Tan}\theta\,(3 - \mathrm{Tan}^2\theta)}{1 - 3\mathrm{Tan}^2\theta} = \frac{\mathrm{Tan}\,\theta\,(\mathrm{Tan}60^\circ - \mathrm{Tan}\theta)\,(\mathrm{Tan}60^\circ + \mathrm{Tan}\theta)}{(1 + \mathrm{Tan}60^\circ\mathrm{Tan}\theta)\,(1 - \mathrm{Tan}60^\circ\mathrm{Tan}\theta)}$$

$$= \mathrm{Tan}\theta \ \mathrm{Tan}(60^\circ - \theta)\ \mathrm{Tan}(60^\circ+\theta)$$

$$= \frac{\mathrm{Sin}(\theta)\ \mathrm{Sin}(60^\circ-\theta)\ \mathrm{Sin}(60^\circ+\theta)}{\mathrm{Cos}(\theta)\ \mathrm{Cos}(60-\theta)\ \mathrm{Cos}(60+\theta)}$$

The above equation is Eq. 2 in Hall's article, which proves to be the same as Eq. 10

Thus, Hall's theory that Eq. 10 is the same as Eq. 2, establishing the geometric relationship that angle MNK is three times the measure of angle MCK, is proved.

CADD Skill Standards Development Project

The Foundation for Industrial Modernization (FIM), in conjunction with the business, education and labor organization, has undertaken a 36-month project under a grant from the U.S. Department of Education to a) develop skill standards for Computer Aided Design and Drafting (CADD) and b) to develop a national, voluntary testing and certification program for individual CADD users.

A skill standard consists of a technical skill plus the academic and employability skills that relate to it. All skills have to be generic (i.e., not software specific), voluntary (available but not mandatory), and core (pertinent to all CADD applications).

The entire document contains the different component of a skill standard. It includes a list of technical skills, a list of employability skills, and an appendix of related academic skills. Only the technical skills are presented here.

After the skills are verified by CADD users, the skills document will serve two purposes. The document, along with other program recommendations, will be made available to schools and industry training programs for incorporation into their curriculum.

Its other purpose will be to serve as a basis upon which test questions can be written for a national, voluntary test for CADD users. It is anticipated that this test will serve as a hiring tool for employers and a means for employees to prove their competence. This test will remain strictly voluntary.

The project staff and committee members welcome your feedback on the project. Any additional questions should be directed to project staff as (202) 637-3438.

Preface

A. All skills contained in Fundamental Drafting Skills Section must be performed in a CADD environment.

B. CADD skills must be performed in accordance with appropriate industry standards.

FUNDAMENTAL DRAFTING SKILLS

Drafting Skills

Use drawing media and consumable materials
Use basic metrology systems with fractions, decimals and metric measurements
Add correct annotation to drawing
Identify line styles, weights
Prepare title blocks and other drafting formats
Apply metric drawing standards
Identify and use appropriate standard symbols
Reproduce originals using different methods
Create freehand technical sketches

Orthographic Projections

Orthographic views
Identify appropriate views
Place appropriate views
Auxiliary Views
Construct auxiliary views to determine true size, shape, and location of non-orthogonal features
Identify and place appropriate views
Utilize various material patterns in section
Construct a full, half and offset section of an object
Construct aligned section of an object with holes, ribs, or spokes
Construct an assembly section
Construct conventional breaks
Construct removed section of an object
Construct revolved section of an object
Construct rib section of an object

Pictorial Drawings

Axonometric
Construct axonometric drawings
Oblique
Construct oblique drawings
Perspective
Identify perspective drawing

Dimensioning

Apply dimensioning rules correctly
Use correct dimension line terminators
Dimension objects
Dimension complex shapes
Dimension features on a center line
Dimension a theoretical point of intersection
Use appropriate duel dimensioning standards

Use feature and location dimension practices
Use various dimensioning styles
Place tolerance dimensioning on drawings.

FUNDAMENTAL COMPUTER SKILLS

Hardware
Protect and maintain equipment
Operate and adjust input devices
Correct handling and operation of storage media
Start and shut down work station
Adjust monitor controls for maximum comfort and usability
Access information services

Physical and Safety Needs
Ergonomics
Personal safety

Operating Systems
Start and exit a software program as required
Demonstrate proper file management techniques
Translate, import, and export data files between formats
Use on-line help
Save drawings to storage devices

BASIC CADD SKILLS

The following skills must be performed in 2D and/or 3D.

Create
Create new drawing
Perform drawing setup
Construct geometric figures
Create text using appropriate style and size to annotate drawings
Use and control accuracy enhancement tools
Create symbols
Create wireframe models via data entry
Create objects using primitives
Perform Boolean operations
Create 2-D geometry from 3-D models
Revolve a profile to create an object
Create 3-D models from 2-D information

Edit
Edit existing drawing
Utilize geometry editing commands
Utilize editing commands

Manipulate
Control coordinates and display scale
Control entity properties
Use viewing commands
Use display commands
Use standard parts and symbol libraries
Plot drawings on media using correct layout and scale
Use layering techniques
Use grouping techniques
Minimize file size
Manipulate symbols

Analyze
Use query commands to interrogate database

Dimensioning
Use associative dimensioning correctly

ADVANCED CADD SKILLS

Create
Create wireframe models via surface intersection
Create non-analytic surfaces using appropriate modeling
Create analytic surfaces using appropriate modeling with planes and analytic curves
Create offset surfaces
Find intersection of two surfaces
Create feature based geometry
Create cut sections
Join surfaces to create boundary-rep solid
Construct and label exploded assembly drawings
Create a fillet or blend between two surfaces

Edit
Trim surface
Edit control points
Manipulate surface normals
Modify Boolean operations
Edit primitives
Extend surface

Manipulate
Clip in the Z axis for viewing
Extract wireframe data from surfaces
Render object

Analyze
Extract geometric data
Extract attribute data
Identify gaps in surfaces
Obtain surfaces properties
Obtain mass properties data

CADD Productivity and Work Habits
Perform customization to improve productivity
Manipulate associated non-graphical data
Use template and library files to establish drawing standard presets
Develop geometry using parametric or variational programs

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