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ENGINEERING DESIGN GRAPHICS JOURNAL OBJECTIVES:

The objectives of the JOURNAL are:

1. To publish articles of interest to teachers of Engineering Graphics, Computer Graphics and allied subjects.
2. To stimulate the preparation of articles and papers on the following topics (but not limited to them):
   - A. Engineering Graphics
   - B. Creative Design
   - C. Research in Graphics
   - D. Graphic Methods
   - E. Computer Graphics
   - F. Teaching Methods and Techniques
3. To encourage teachers of Graphics to innovate on, experiment with, and test appropriate techniques and topics to further improve quality of and modernize instruction and courses.

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1972-73 -- Denver, Colorado
1973-74 -- New Orleans, Louisiana
1974-75 -- Williamsburg, Virginia

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proudly announces that Mr. Arnold Cammarata, formerly Vice-President of Marketing at Teledyne-Post, is now joining our firm.

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Paul Oppenheimer

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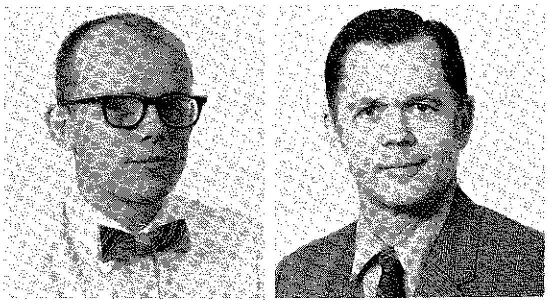


MATHEMATICS AND GRAPHICS -- GETTING THE POINT ACROSS - AGAIN?

L. C. Baird & Frank F. Marvin
Virginia Polytechnic Institute and State University

I INTRODUCTION

This is the second in a series of articles designed to assist teachers of freshman engineering students in their effort to "get the point across" that mathematics and engineering graphics are related subjects fundamental to practical engineering.

The initial article of the series[1] helped "get the point across" by comparing three techniques (calcus, vector analysis, and descriptive geometry) for finding the shortest distance between two skew lines. Reader interest and requests for transparencies have prompted this second illustration, which applies the same techniques to a problem involving angles rather than distances.

This problem is the determination of the angle between any given line and any given plane. The typical student may regard this as a purely academic exercise. It is therefore profitable to introduce the topic by citing practical examples in which the engineer might actually need line-plane angles in the design of brackets, supports, jigs and various other fixtures. Having thus identified the problem, the teacher can introduce the three-fold presentation of sections II, III, and IV. The presentation is more effective if it begins with projected transparencies[2], thus giving the students a condensed visual impression of the three techniques. The teacher may, at this time, wish to comment on the relative merits of the various techniques[3]. For example, the graphical solution is easily learned and easily applied; but it may be inadequate if the application demands extreme accuracy or if the numerical data has peculiarities which cannot be conveniently plotted. The mathematical solutions, on the other hand, offer accuracy and flexibility; but they involve tedious calculations and require a thorough grasp of somewhat sophisticated mathematical concepts. Having thus "gotten the point across", the teacher can now proceed with a detailed consideration of the required course material (e. g., the graphical solution).

The several solutions each begin with the data in FIGURE 1: two points (U and V) which determine a line and three points (A, B, and C) which determine a plane. Sections II and III attack the problem with the calculus and with vector analysis. Section IV presents the graphical solution.

II. THE CALCULUS SOLUTION

In this section the problem is solved with the following two-step procedure:

1) Differentiation is used to determine points (U_o and V_o) of the $\overline{ABC}$ plane which are closest to U and V. The points U_o and V_o are the projections of U and V onto $\overline{ABC}$.

2) The line-plane angle, θ, is computed as in FIGURE 2 from the distances $d(U, V)$ and $d(U_o, V_o)$.

To accomplish step (1) it is necessary to know the equation of the plane. This equation must have the general form:

$$k = px + qy + rz \qquad (1)$$

where k, p, q, and r are to be determined. But equation (1) must be satisfied by the coordinates of each of the points A, B, C. Thus, the coordinates of FIGURE 1 yield:

$$k = 30p + 60q + 70r \qquad (2a)$$

$$k = 15p + 75q + 50r \qquad (2b)$$

$$k = 40p + 90q + 50r \qquad (2c)$$

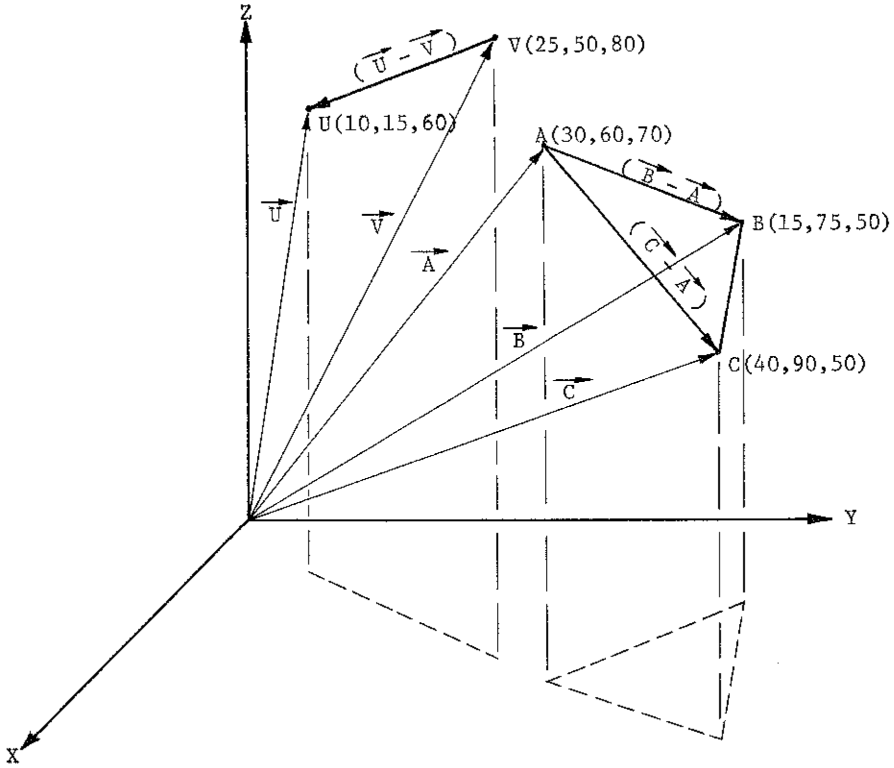


Fig. 1 -- Oblique pictorial of the $\overline{UV}$ line and the $\overline{ABC}$ plane.

These equations may be solved simultaneously for the unknown coefficients:

$$p = -3k/630 \tag{3a}$$

$$q = 5k/630 \tag{3b}$$

$$r = 6k/630 \tag{3c}$$

These results can now be used in equation (1):

$$k = (-3k/630)x + (5k/630)y + (6k/630)z \tag{4}$$

This simplifies to:

$$630 = -3x + 5y + 6z \tag{5}$$

which is the desired equation for the $\overline{ABC}$ plane.

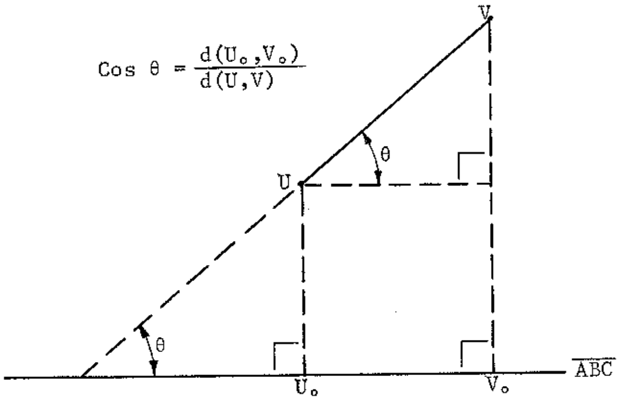


Fig. 2 -- Finding θ in step (2) of the calculus solution.

The distance from U to a point (x, y, z) is given by the Pythagorean theorem:

$$S_U = \left[(x - 10)^2 + (y - 15)^2 + (z - 60)^2\right]^{.5} \tag{6}$$

If the point (x, y, z) is in the $\overline{ABC}$ plane then one may use equation (5) to eliminate z and obtain:

$$S_U = \left[(x - 10)^2 + (y - 15)^2 + \left(\frac{630 + 3x - 5y}{6} - 60\right)^2\right]^{.5} \tag{7}$$

The distance S_U is a minimum if:

$$0 = \frac{\partial}{\partial x} S_U \tag{8a}$$

$$0 = \frac{\partial}{\partial y} S_U \tag{8b}$$

These derivatives are:

$$0 = \left[(x - 10) + \left(\frac{630 + 3x - 5y}{6} - 60\right)/2\right] \div S_U \tag{9a}$$

$$0 = \left[(y - 15) - 5\left(\frac{630 + 3x - 5y}{6} - 60\right)/6\right] \div S_U \tag{9b}$$

Equations (9) can be solved simultaneously to obtain:

$$x = 5/14 \qquad (10a)$$

$$y = 435/14 \qquad (10b)$$

Equations (5), (10a), and (10b) can be solved simultaneously to obtain:

$$z = 1110/14 \qquad (10c)$$

That is:

$$U_o = (5/14\ ,\ 435/14\ ,\ 1110/14) \qquad (11)$$

The point V_o is defined and computed in an analogous manner. The result is:

$$V_o = (365/14\ ,\ 675/14\ ,\ 1090/14) \qquad (12)$$

The line-plane angle can now be determined as in FIGURE 2:

$$\cos\theta = \frac{d(U_o\ ,\ V_o)}{d(\ U\ ,\ V\ )} \qquad (13$$

$$= \left[\left(\frac{5}{14} - \frac{365}{14}\right)^2 + \left(\frac{435}{14} - \frac{675}{14}\right)^2 + \left(\frac{1110}{14} - \frac{1090}{14}\right)^2\right]^{.5}$$

$$\div \left[(10 - 25)^2 + (15 - 50)^2 + + (60 - 80)^2\right]^{.5} \qquad (13)$$

Therefore:

$$\theta = 44° \qquad (14)$$

which is the required angle.

III VECTOR ANALYSIS SOLUTION

The vector analysis solution also follows a two-step procedure:

1) Find a vector $\vec{L}$ along the line plus a vector $\vec{N}$ normal to the plane.

2) The angle θ is inferred from the dot product $\vec{L} \cdot \vec{N}$.

To accomplish step (1), observe (see FIGURE 1) that the differences, $(\vec{A} - \vec{B})$ and $(\vec{A} - \vec{C})$, are vectors from $\vec{B}$ to $\vec{A}$ and from $\vec{C}$ to $\vec{A}$, respectively[4]. Furthermore, these differences are embedded in the $\overline{ABC}$ plane; their cross product is therefore normal to the plane:

$$\vec{N} = (\ \vec{A} - \vec{B}\ ) \times (\ \vec{A} - \vec{C}\ ) \qquad (15)$$

Furthermore, the $\overline{UV}$ line contains the vector:

$$\vec{L} = \vec{U} - \vec{V} \qquad (16)$$

FIGURE 3 depicts the relationship between $\vec{L}$, $\vec{N}$, and the $\overline{ABC}$ plane.

It is now possible to execute step (2) of the previously outlined procedure. That is:

$$\vec{L}\cdot\vec{N} = |\vec{L}| \cdot |\vec{N}| \cos(90° - \theta)$$

$$= |\vec{L}| \cdot |\vec{N}| \sin\theta \qquad (17)$$

Or:

$$\theta = \sin^{-1} \frac{\vec{L}\cdot\vec{N}}{|\vec{L}| \cdot |\vec{N}|} \qquad (18)$$

It sometimes happens that this formula gives a negative value for θ. If this occurs, equation (15) "should" have been written with the two factors in reverse order (i. e., $\vec{N}$ was pointing backwards). Such confusion is easily avoided by placing absolute value signs around the dot product. That is:

$$\theta = \sin^{-1} \frac{|\vec{L}\cdot\vec{N}|}{|\vec{L}| \cdot |\vec{N}|} \qquad (19)$$

Or, using equations (15) and (16):

$$\theta = \sin^{-1} \frac{|(\ \vec{U} - \vec{V}\ )\cdot(\ \vec{A} - \vec{B}\ ) \times (\ \vec{A} - \vec{C}\ )|}{|\vec{U} - \vec{V}| \cdot |(\ \vec{A} - \vec{B}\ ) \times (\ \vec{A} - \vec{C}\ )|} \qquad (20)$$

where the arcsine is taken to be an acute angle.

Equation (20) is the general formula for the angle between a line and a plane. In particular, the numberical values of FIGURE 1 lead to:

$$|\vec{U} - \vec{V}| = [(10 - 25)^2 + (15 - 50)^2 + (60 - 80)^2]^{.5}$$

$$= 43 \qquad (21)$$

Also:

$$|(\ \vec{A} - B\ ) \times (\ \vec{A} - \vec{C}\ )| = \left\| \begin{matrix} \hat{x} & \hat{y} & \hat{z} \\ 30 - 15 & 60 - 75 & 70 - 50 \\ 30 - 40 & 60 - 90 & 70 - 50 \end{matrix} \right\|$$

$$= |300\,\hat{x} - 500\,\hat{y} - 600\,\hat{z}|$$

$$= (300^2 + 500^2 + 600^2)^{.5}$$

$$= 837 \qquad (22)$$

Where $\hat{x}$, $\hat{y}$, and $\hat{z}$ are unit vectors along the coordinate axes. Equation (20) involves yet one more product, namely:

$$\left|(\vec{U} - \vec{V}) \cdot (\vec{A} - \vec{B}) \times (\vec{A} - \vec{C})\right| =$$

$$\left\| \begin{matrix} 10 - 25 & 15 - 50 & 60 - 80 \\ 30 - 15 & 60 - 75 & 70 - 50 \\ 30 - 40 & 60 - 90 & 70 - 50 \end{matrix} \right\|$$

$$= |25{,}000|$$

$$= + 25{,}000 \qquad (23)$$

Thus:

$$\theta = \sin^{-1} \frac{25{,}000}{43 \cdot 837}$$

$$= 44^\circ \qquad (24)$$

which is in agreement with the calculus solution in equation (15).

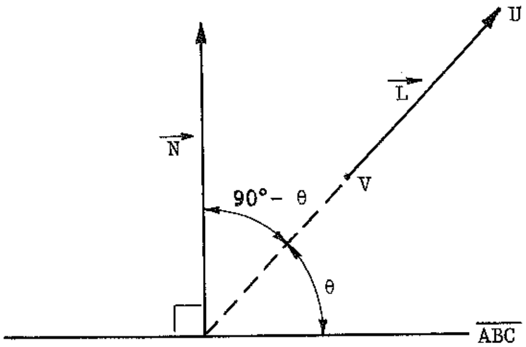


Fig. 3 - Vectors used in step (2) of the vector solution.

IV. THE GRAPHICAL SOLUTION

To determine the angle between a line and any plane, it is necessary to obtain a view that shows a normal or true length view of the line and an edge view of the plane. The required angle can then be measured directly. The general solution to this problem requires three auxiliary views; however, either of two approaches may be used as illustrated in FIGURES 4 and 5.

(Continued on the next page)

* * *

Given the line $\overline{UV}$ and the plane $\overline{ABC}$ in FIGURE 4, construct first and second auxiliary views to obtain the normal or true shape view of the plane. Any view projected from the second auxiliary view will show the plane in edge. Therefore, project to a third auxiliary view perpendicular to the given line. This view will show the true length of the line and an edge view of the plane. The true angle between the line and the plane can be measured directly, as indicated.

Given the line $\overline{UV}$ and the plane $\overline{ABC}$ in FIGURE 5, construct first and second auxiliary views to obtain the end or point view of the line. Any view projected from the second auxiliary view will show the line true length. Therefore, project to a third auxiliary view so that the plane will appear in edge. This view will show the true length of the line and an edge view of the plane. The angle between the line and the plane can be measured directly, as indicated.

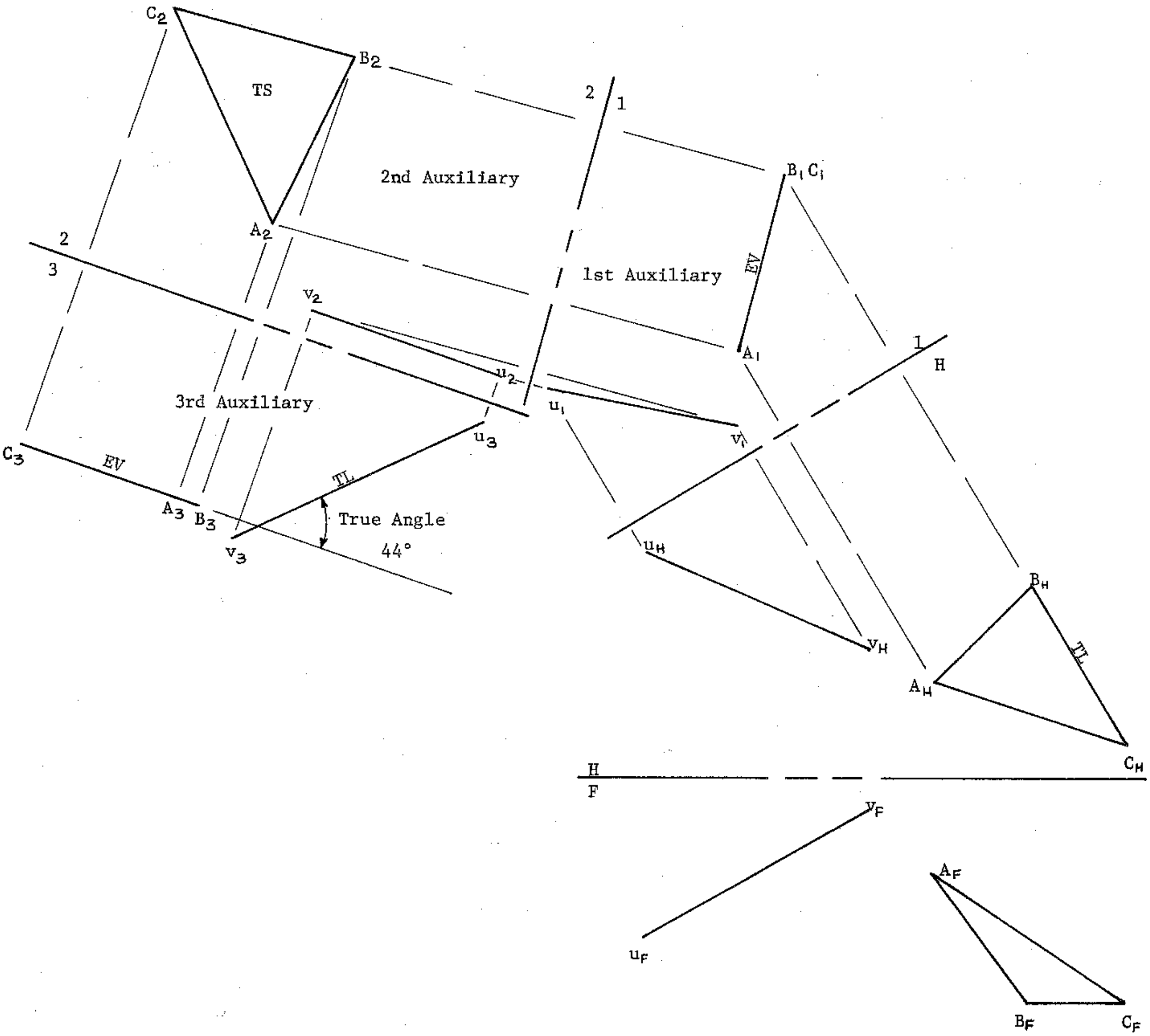


Fig. 4 -- Angle between a line and any plane:
first method.

V. FINAL COMMENTS

It would now be appropriate to simply repeat sections V and VI of our previous paper[1]. We will, however, restrict ourselves to a final assertion that the threefold presentation[2] does indeed "get the point across".

REFERENCES

1. L. C. Baird and Frank Marvin; Engineering Design Graphics Journal; page 17, volume 36, number 3 (fall 1972)
2. Xerox transparencies can readily be produced from drawings which the authors will supply upon request. Please specify the paper(s) for which you desire drawings.
3. The reader is referred to the previous paper for a fuller comparison.
4. See FIGURE 1.

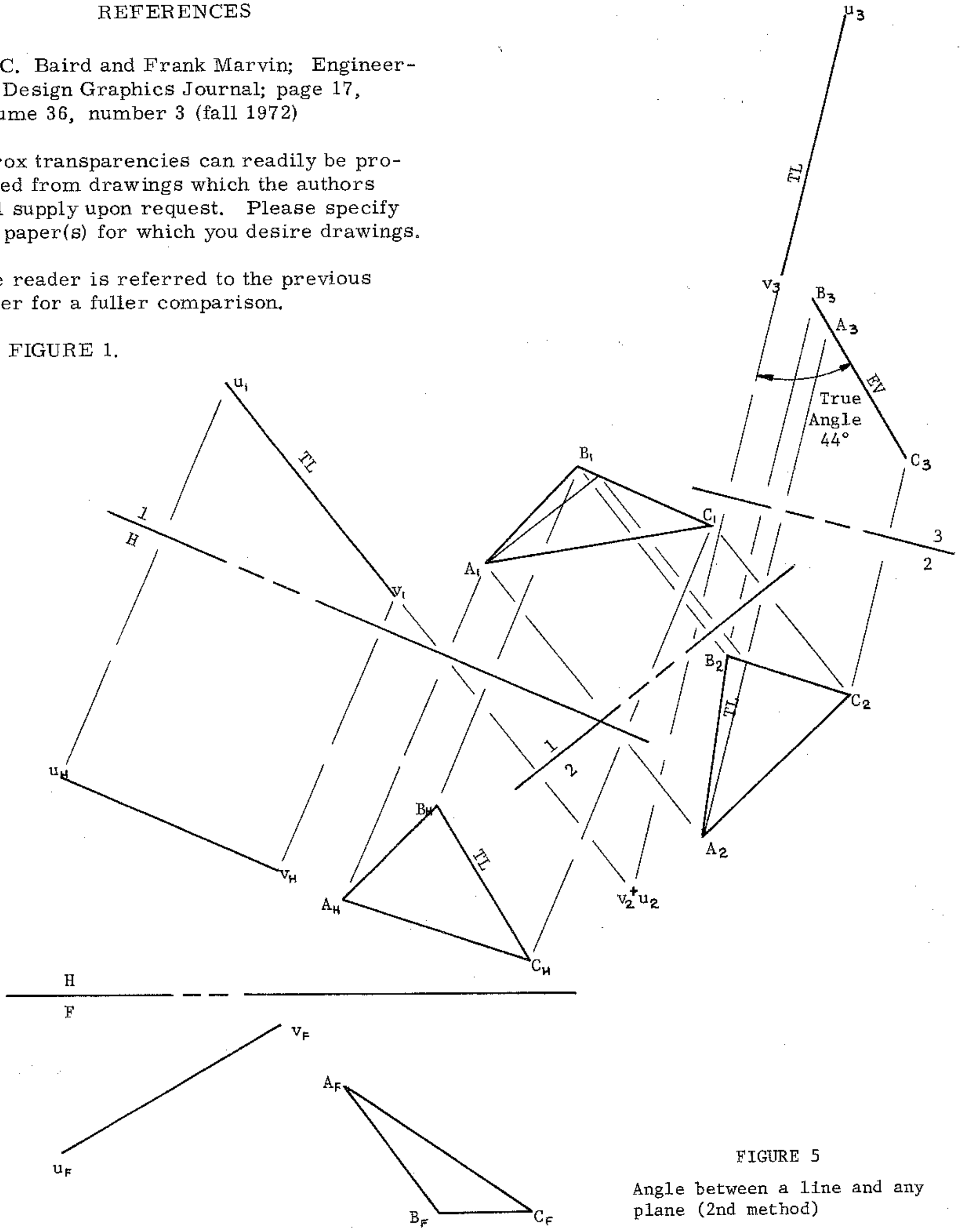
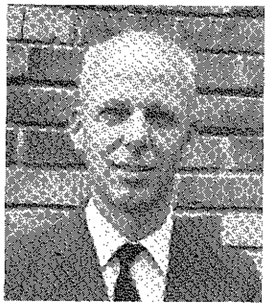


FIGURE 5

Angle between a line and any plane (2nd method)

Fig. 5 -- Angle between a line and any plane: second method.



COMPUTER MEDIATED INSTRUCTION PROGRAMS IN ENGINEERING GRAPHICS

Professor Klaus E. Kroner
University of Massachusetts

Introduction

With the installation of a remote-access computer system on the University of Massachusetts campus, a new educational tool was placed before students and faculty alike. Although these campus-wide facilities went into operation some two years ago, I am certain that the full benefits to be derived from it have even today not yet been fully realized.

One of the advantages currently recognized is the possibility of using the system in the conversational mode, rather than for purely problem solving purposes. The author witnessed a demonstration of this type of computer utilization at the 1968 Annual Meeting of the Association of American Geographers in Washington, D. C. There, at the place of the meeting, the Department of Geography at Dartmouth College had set up a few portable teletype units which were linked to a computer located elsewhere in the city. Programs, related to their courses on climatology were stored in this computer system and thus accessible to persons attending the meeting. Their programs were written in a way that the user was quickly absorbed in a concentrated conversation with the computer. The originator of that material was Professor Robert E. Huke whose work is described in a recent publication by the Association of American Geographers. [1]

It was from the above example that this author applied the idea to the subject of Engineering Graphics. Conversational programs have also been developed in college physics instruction[2], and there is really no reason why tutorial computer programs can not be written for any subject.

Objectives

The principal objective of writing programs of this type is to provide students with another medium of study. The teletype does not take the place of the classroom lecture, nor is it intended to eliminate the textbook. As a matter of fact, it would be presumed that the students have already had instruction in the subject and have studied the material on their own (the author recognizes that the latter rarely occurs) before utilizing the computer facilities. The instructional programs presented here should be considered tutorial in nature.

A purely secondary objective is to demonstrate to the students still another use of the computer--the conversational mode, assuming that, since these are engineering students, they are already keenly aware of the computational capabilities of the equipment.

Programming Aspects

The author used the BASIC computer language, which lends itself reasonably well to programs which require relatively little calculation but necessitate lengthy verbal outputs. Other languages may well be more efficient or more suitable, but BASIC happened to be available for our CDC 3600 computer at the time the programs were initially written (Fall 1968).

Part of one of the computer programs appears in figure 1. To have sentences printed on the teletype, one precedes the sentence by the word PRINT and places quotation marks before and after the sentence, such as statement no. 008. A sentence too long to fit on one line will require enough additional program statements until all of the sentence has been accommodated (lines 009 and 010). A blank PRINT statement causes the teletype to skip one line and is used to separate paragraphs or questions for emphasis.

Whatever answer to a question is given by the user, an appropriate reply is selected through the mechanism of an INPUT statement followed by several IF statements (see lines 028 to 032). To facilitate editing, correcting, or lengthening the program, means of by-passing certain portions of the program have been built in. If, for example, the programmer should type in the number 100 rather than the 1, 2, or 3 provided for the student user, line 029 will immediately cause the computer to proceed directly to the last question in the program. Similarly, according to statement

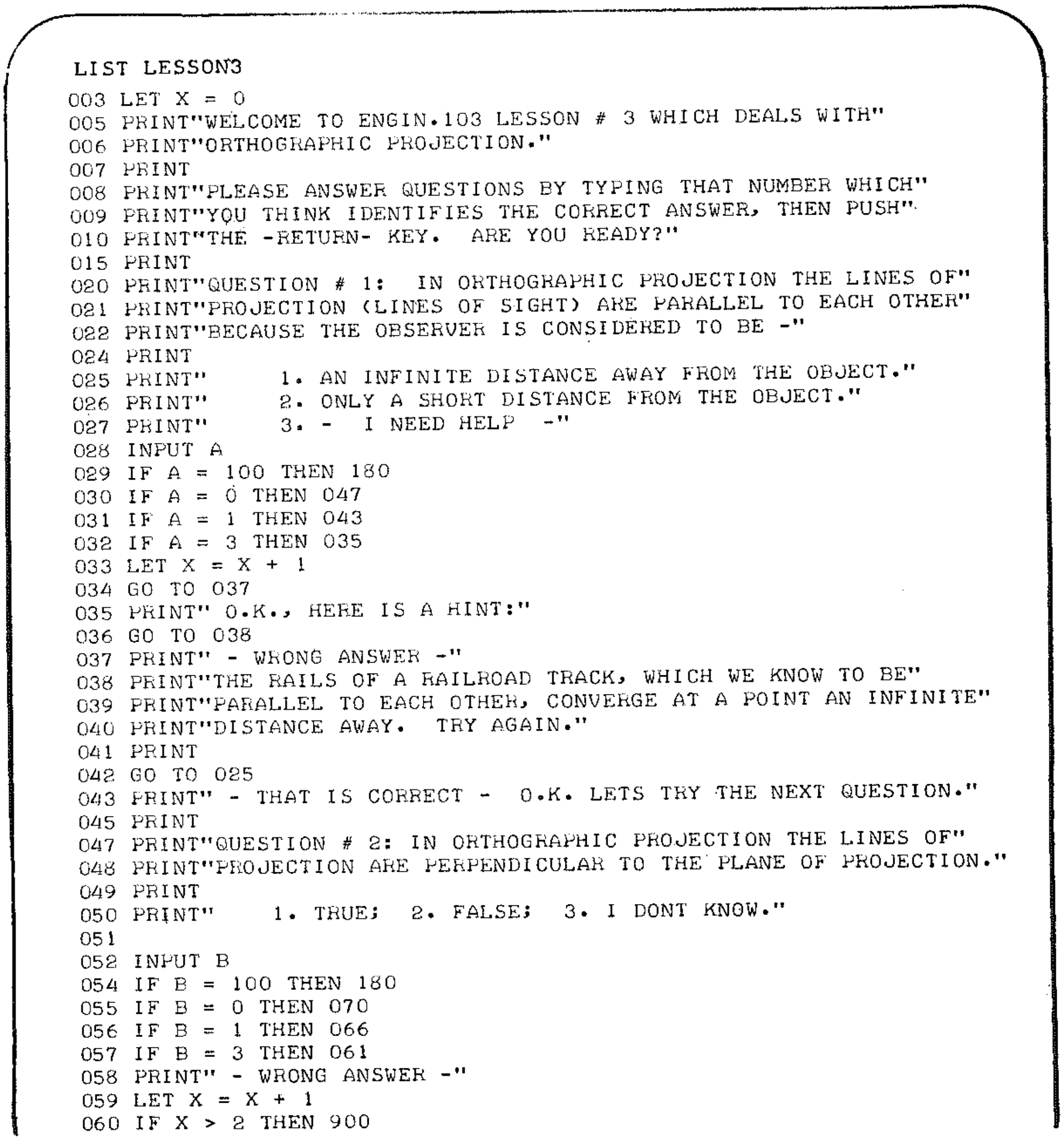
030, a 0 would by-pass all computer replies to question 1 and continue with question 2.

Provisions are also made for keeping track of incorrect responses made by the student (lines 003, 033, etc.). An accumulation of three errors will cause the program to abort with the final reprimand that he ought to try the program again after doing some more studying (see fig. 4). Fewer than three mistakes will produce less harsh parting comments while a student with a perfect score will be awarded with the encouraging remark "EXCELLENT, GOOD LUCK AND GOODBYE".

Pedagogical Aspects

Although a series of topical programs were originally planned, various circumstances allowed the author to formulate only three thus far. These deal with orthographic projection, pictorial representation and fundamentals of descriptive geometry.

Each program consists of a series of questions relating to the topic at hand. Sometimes the student is asked to verify the correctness of a given statement. An example is shown in figure 2. Here he is given a choice of three responses each of which will produce an analytical statement on the teletype paper. On this particular question, you will note, the student is given the opportunity to admit that he does not know the answer, in which case he would elect to push the "3" key. He is then supplied with a hint by attempting to



```
LIST LESSON3
003 LET X = 0
005 PRINT"WELCOME TO ENGIN.103 LESSON # 3 WHICH DEALS WITH"
006 PRINT"ORTHOGRAPHIC PROJECTION."
007 PRINT
008 PRINT"PLEASE ANSWER QUESTIONS BY TYPING THAT NUMBER WHICH"
009 PRINT"YOU THINK IDENTIFIES THE CORRECT ANSWER, THEN PUSH"
010 PRINT"THE -RETURN- KEY.  ARE YOU READY?"
015 PRINT
020 PRINT"QUESTION # 1:  IN ORTHOGRAPHIC PROJECTION THE LINES OF"
021 PRINT"PROJECTION (LINES OF SIGHT) ARE PARALLEL TO EACH OTHER"
022 PRINT"BECAUSE THE OBSERVER IS CONSIDERED TO BE -"
024 PRINT
025 PRINT"      1. AN INFINITE DISTANCE AWAY FROM THE OBJECT."
026 PRINT"      2. ONLY A SHORT DISTANCE FROM THE OBJECT."
027 PRINT"      3. -  I NEED HELP  -"
028 INPUT A
029 IF A = 100 THEN 180
030 IF A = 0 THEN 047
031 IF A = 1 THEN 043
032 IF A = 3 THEN 035
033 LET X = X + 1
034 GO TO 037
035 PRINT" O.K., HERE IS A HINT:"
036 GO TO 038
037 PRINT" - WRONG ANSWER -"
038 PRINT"THE RAILS OF A RAILROAD TRACK, WHICH WE KNOW TO BE"
039 PRINT"PARALLEL TO EACH OTHER, CONVERGE AT A POINT AN INFINITE"
040 PRINT"DISTANCE AWAY.  TRY AGAIN."
041 PRINT
042 GO TO 025
043 PRINT" - THAT IS CORRECT -  O.K. LETS TRY THE NEXT QUESTION."
045 PRINT
047 PRINT"QUESTION # 2: IN ORTHOGRAPHIC PROJECTION THE LINES OF"
048 PRINT"PROJECTION ARE PERPENDICULAR TO THE PLANE OF PROJECTION."
049 PRINT
050 PRINT"     1. TRUE;  2. FALSE;  3. I DONT KNOW."
051
052 INPUT B
054 IF B = 100 THEN 180
055 IF B = 0 THEN 070
056 IF B = 1 THEN 066
057 IF B = 3 THEN 061
058 PRINT" - WRONG ANSWER -"
059 LET X = X + 1
060 IF X > 2 THEN 900
```

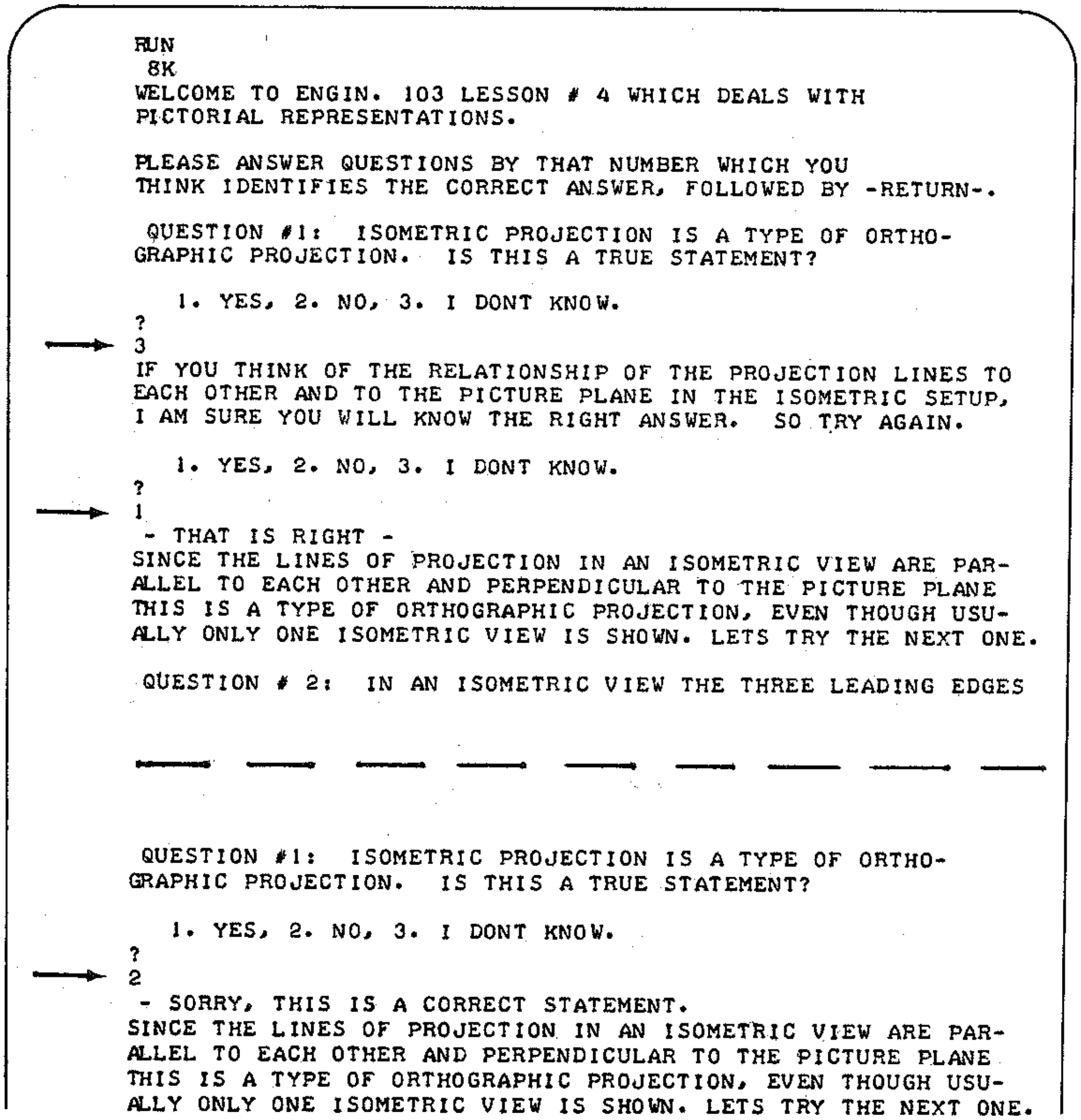
fig. 1 — A typical program

recall his memory to an appropriate pertinent fact of theory. The user is given a second chance to answer the question correctly. This route through the program is not tabulated as an "error". The computer response for the incorrect answer #2 is also shown in figure 2.

The computer can also be programmed to print out simple graphical displays, one of which is shown in figure 3. Several questions can then be asked about that illustration.

Incidentally, you will notice that the possible responses need not be limited to three, any number within reason could be programmed. In fact, the entire programming effort is limited only by the ingenuity and imagination of the programmer. The main emphasis here has been to guide the student through a series of analytical steps in basic graphics theory and assist him to think the problem through to a logical answer. The temptation on the part of the student to substitute a rational answer by simply pushing a key at random is tempered by the frequent offers of assistance.

It may correctly be pointed out that this approach has already been exemplified by teaching machines and other programmed instruction devices. These, however, were not generally available on our campus, while remote access terminals are a common sight and students, at least those in engineering, are conditioned to use them without hesitation. It should also be noted that it matters not whether the potential user of these programs had any previous experience with computers or programming. All interested graphics students were supplied with a sheet of instructions for operating the teletype, signing on, and calling for a specific program. The rest of the operation is automatic.

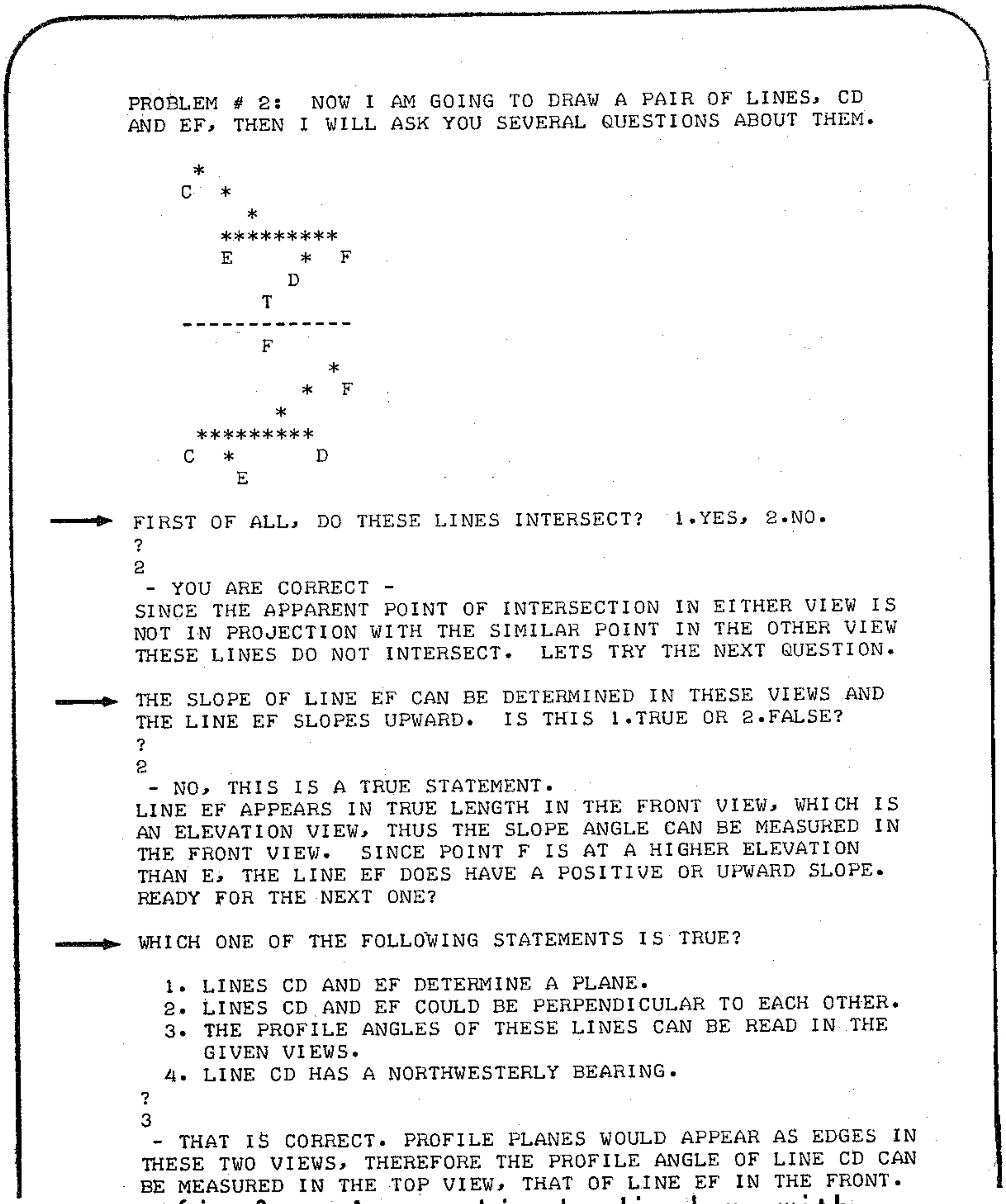


```
RUN
 8K
WELCOME TO ENGIN. 103 LESSON # 4 WHICH DEALS WITH
PICTORIAL REPRESENTATIONS.

PLEASE ANSWER QUESTIONS BY THAT NUMBER WHICH YOU
THINK IDENTIFIES THE CORRECT ANSWER, FOLLOWED BY -RETURN-.

 QUESTION #1:  ISOMETRIC PROJECTION IS A TYPE OF ORTHO-
GRAPHIC PROJECTION.  IS THIS A TRUE STATEMENT?

   1. YES, 2. NO, 3. I DONT KNOW.
?
3
IF YOU THINK OF THE RELATIONSHIP OF THE PROJECTION LINES TO
EACH OTHER AND TO THE PICTURE PLANE IN THE ISOMETRIC SETUP,
I AM SURE YOU WILL KNOW THE RIGHT ANSWER.  SO TRY AGAIN.

   1. YES, 2. NO, 3. I DONT KNOW.
?
1
 - THAT IS RIGHT -
SINCE THE LINES OF PROJECTION IN AN ISOMETRIC VIEW ARE PAR-
ALLEL TO EACH OTHER AND PERPENDICULAR TO THE PICTURE PLANE
THIS IS A TYPE OF ORTHOGRAPHIC PROJECTION, EVEN THOUGH USU-
ALLY ONLY ONE ISOMETRIC VIEW IS SHOWN. LETS TRY THE NEXT ONE.

 QUESTION # 2:  IN AN ISOMETRIC VIEW THE THREE LEADING EDGES


-----  -----  -----  -----  -----  -----  -----  -----  -----


 QUESTION #1:  ISOMETRIC PROJECTION IS A TYPE OF ORTHO-
GRAPHIC PROJECTION.  IS THIS A TRUE STATEMENT?

   1. YES, 2. NO, 3. I DONT KNOW.
?
2
 - SORRY, THIS IS A CORRECT STATEMENT.
SINCE THE LINES OF PROJECTION IN AN ISOMETRIC VIEW ARE PAR-
ALLEL TO EACH OTHER AND PERPENDICULAR TO THE PICTURE PLANE
THIS IS A TYPE OF ORTHOGRAPHIC PROJECTION, EVEN THOUGH USU-
ALLY ONLY ONE ISOMETRIC VIEW IS SHOWN. LETS TRY THE NEXT ONE.
```

fig. 2 – A question and three responses

Results and Conclusions

The use of this study aid was entirely at the discretion of the students. They were simply informed that the programs were available. Thus, this activity was not a required part of the graphics courses. Through our billing procedures it was discovered that many students availed themselves of the tutoring service just prior to scheduled examinations, while for the remainder of the time demand slackened off considerably. No attempt was made to measure the effectiveness of the programs, and no claim is made that they are superior to any other teaching method. They are presented here merely as another example of what can be done without great expense or effort. Once the initial steps in writing a program which works from the operational point of view are learned, it is fairly easy to develop an instructional computer program. From those students who did try to reinforce their knowledge of engineering graphics via the teletype many unsolicited favorable remarks were



```
PROBLEM # 2:  NOW I AM GOING TO DRAW A PAIR OF LINES, CD
AND EF, THEN I WILL ASK YOU SEVERAL QUESTIONS ABOUT THEM.

     *
    C  *
         *
       *********
       E     *  F
            D
          T
    -------------
          F
               *
             *  F
           *
     *********
    C  *      D
        E

FIRST OF ALL, DO THESE LINES INTERSECT?  1.YES, 2.NO.
?
2
 - YOU ARE CORRECT -
SINCE THE APPARENT POINT OF INTERSECTION IN EITHER VIEW IS
NOT IN PROJECTION WITH THE SIMILAR POINT IN THE OTHER VIEW
THESE LINES DO NOT INTERSECT.  LETS TRY THE NEXT QUESTION.

THE SLOPE OF LINE EF CAN BE DETERMINED IN THESE VIEWS AND
THE LINE EF SLOPES UPWARD.  IS THIS 1.TRUE OR 2.FALSE?
?
2
 - NO, THIS IS A TRUE STATEMENT.
LINE EF APPEARS IN TRUE LENGTH IN THE FRONT VIEW, WHICH IS
AN ELEVATION VIEW, THUS THE SLOPE ANGLE CAN BE MEASURED IN
THE FRONT VIEW.  SINCE POINT F IS AT A HIGHER ELEVATION
THAN E, THE LINE EF DOES HAVE A POSITIVE OR UPWARD SLOPE.
READY FOR THE NEXT ONE?

WHICH ONE OF THE FOLLOWING STATEMENTS IS TRUE?

  1. LINES CD AND EF DETERMINE A PLANE.
  2. LINES CD AND EF COULD BE PERPENDICULAR TO EACH OTHER.
  3. THE PROFILE ANGLES OF THESE LINES CAN BE READ IN THE
     GIVEN VIEWS.
  4. LINE CD HAS A NORTHWESTERLY BEARING.
?
3
 - THAT IS CORRECT. PROFILE PLANES WOULD APPEAR AS EDGES IN
THESE TWO VIEWS, THEREFORE THE PROFILE ANGLE OF LINE CD CAN
BE MEASURED IN THE TOP VIEW, THAT OF LINE EF IN THE FRONT.
```

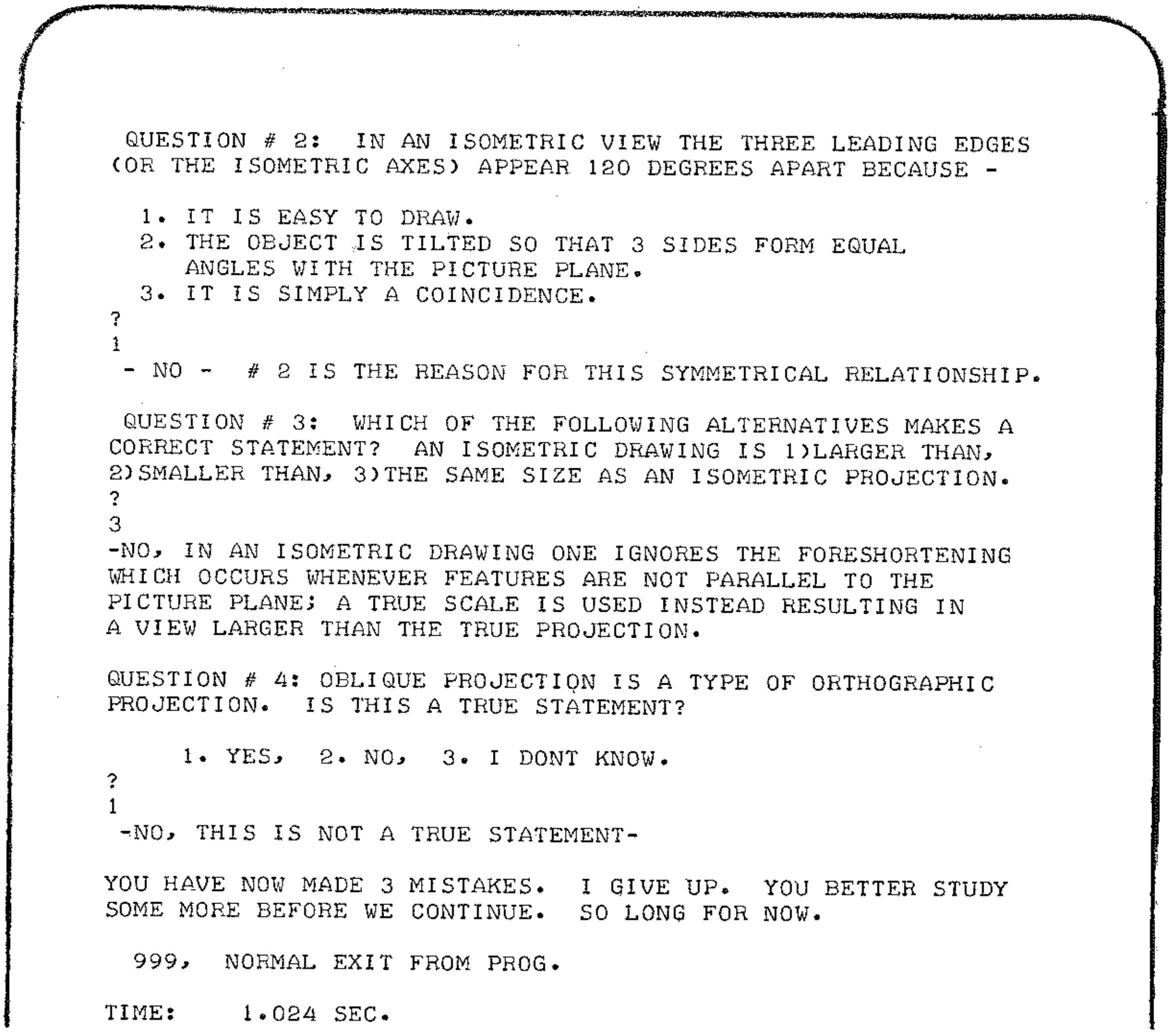
fig. 3 — A graphical display with several questions

received, and that is what makes the whole effort worthwhile.

---

1). Computer Assisted Instruction in Geography, A. A. G. Commission on College Geography, Technical Paper #2 (1969)

2). G. Schwartz, et al, "Computers in Physics Instruction", Physics Today, September 1969, pp. 41-49.



```
 QUESTION # 2:  IN AN ISOMETRIC VIEW THE THREE LEADING EDGES
(OR THE ISOMETRIC AXES) APPEAR 120 DEGREES APART BECAUSE -

   1. IT IS EASY TO DRAW.
   2. THE OBJECT IS TILTED SO THAT 3 SIDES FORM EQUAL
      ANGLES WITH THE PICTURE PLANE.
   3. IT IS SIMPLY A COINCIDENCE.
?
1
 - NO -  # 2 IS THE REASON FOR THIS SYMMETRICAL RELATIONSHIP.

 QUESTION # 3:  WHICH OF THE FOLLOWING ALTERNATIVES MAKES A
CORRECT STATEMENT?  AN ISOMETRIC DRAWING IS 1)LARGER THAN,
2)SMALLER THAN, 3)THE SAME SIZE AS AN ISOMETRIC PROJECTION.
?
3
-NO, IN AN ISOMETRIC DRAWING ONE IGNORES THE FORESHORTENING
WHICH OCCURS WHENEVER FEATURES ARE NOT PARALLEL TO THE
PICTURE PLANE; A TRUE SCALE IS USED INSTEAD RESULTING IN
A VIEW LARGER THAN THE TRUE PROJECTION.

QUESTION # 4: OBLIQUE PROJECTION IS A TYPE OF ORTHOGRAPHIC
PROJECTION.  IS THIS A TRUE STATEMENT?

     1. YES,   2. NO,   3. I DONT KNOW.
?
1
 -NO, THIS IS NOT A TRUE STATEMENT-

YOU HAVE NOW MADE 3 MISTAKES.  I GIVE UP.  YOU BETTER STUDY
SOME MORE BEFORE WE CONTINUE.  SO LONG FOR NOW.

  999,  NORMAL EXIT FROM PROG.

TIME:    1.024 SEC.
```

fig. 4 — The conversational mode

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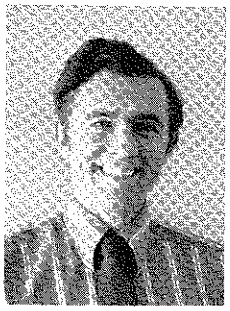


A MODIFIED SELF-PACED COURSE IN DESCRIPTIVE GEOMETRY

Ronald C. Pare'

Cogswell Polytechnical College

Introduction

Self-Paced Instruction Methods are as varied as the number of courses being taught using the technique. The goal of all self-paced courses is the same; however, increased learning by allowing the individual student to proceed through the course material at his own rate with personalized instructor assistance as required. The implementation of any self-paced course is basically the same and ideally contains the following features:

1. The subject material is divided into small units, each unit containing a defined objective, textbook reading assignment, explanatory study problems and a proficiency examination.
2. A programmed textbook
3. Video-taped mini-lectures for each unit of instruction with the provision for unlimited viewing by the students.
4. One-hundred percent proficiency in a unit before proceeding.
5. A guaranteed "A" grade if the course is completed.
6. Unlimited time for the student to complete the course.

Due to limited financial support and limitations imposed by the college and state university system, alternatives to some of the concepts of a self-paced course had to be employed for the experimental descriptive geometry course.

The Technique Used

A programmed text and video-tape facilities were not available. Also, the state university system insists upon a grade being given each student at the end of a quarter and the college disapproves of incompletes. This grading restriction precluded 100% efficiency and therefore the guaranteed "A". With these limitations a controlled self-paced course was designed. The course contained the following features:

1. Eleven units of instructional material, each containing a defined subject area, textbook reading assignment, mini-lecture, study problems, example quiz problem, proficiency quiz stressing application of principles and a required completion date.
2. Descriptive Geometry text with additional references provided.
3. A guaranteed relationship between quiz average and a letter grade.
4. An established and required course completion date allowing one week for each unit of material.

Three sections of the course were offered with the self-pacing format. Each class met twice a week for three hours and the students were encouraged to attend at any of the six meetings held during a week. After second week withdrawals, a total of 50 students were enrolled in the three classes. Each unit of instruction was handled in the same manner. A short lecture introduced the subject area. This lecture lasted from ten to thirty minutes. A student could take the quiz for a unit of material after he had demonstrated understanding in that unit by either completing the study problems or the sample quiz. Most students completed both before attempting a quiz.

A unit quiz could be retaken as many times as desired by the student so long as the final completion date for that particular unit had not passed. A limit of one quiz per day in a unit was established to insure additional preparation of the study material. Quizzes were graded and necessary corrections discussed with the student immediately after completion of the quiz whenever possible. No student had to take more than three quizzes for any one unit. The cases of a student not completing a quiz satisfactorily by the deadline were very infrequent (two) and were handled individually without any adverse effect on the students involved.

As the course progressed, the mini-lecture was abandoned in favor of individual explanation of concepts, due to the variety of subject areas being studied by the class. This made for a tremendous amount of repetition by the instructor but no alternative seemed appropriate since tapes were not available. The individual explanations did allow the instructor to insure that adequate comprehension of the concepts pertaining to the subject were obtained by each student.

The first quiz was a review of the principles of orthographic projection in which 75% of the students received a perfect score on the first day of class. These students were then a week ahead of the deadline schedule. This quiz also served to alert the instructor to the students with a weak background for the course and, as a result, two students were immediately given additional attention and suggested review assignments. The unprepared students were required to drop the course and do not appear in the statistics presented later in this report.

Preparation Required

Once the decision was made to proceed with the experimental course, two major tasks had to be completed. The first was selecting the eleven units of instruction. Then the most difficult and time consuming job was the preparation of the quiz problems.

Dividing the subject matter of the course into eleven units was more difficult than anticipated. With a goal of ten units sought, the first attempt resulted in sixteen. This would be an ideal number for a semester course but not satisfactory for a quarter course. The number was reduced to thirteen but no convenient class schedule could be arranged so a compromise of eleven was established. This allowed for one week to complete each unit when the final exam was eliminated. Once the units were determined, the reading and study problems were assigned from the textbook used at the school. A course outline was prepared and given each student on the first day of class. Figure 1 shows the course outline used.

The preparation of interesting and comprehensive quizzes was a major undertaking. Every reference book available was used to create ideas. Each quiz was designed so the student would have to apply the principles of

Quiz No.	Subject Area	Text Study Assignment	Study Problems	Sample Quiz	Last Day To Complete
1	Review of Orthographic Projection	1.1-1.20	-	-	April 2
2	True Length & Slope of Lines, Edge & True Size Views of a Plane	2.1-2.19	8.5.1,8.6.1, 8.7.3,8.8.2, 8.9.4,8.10.2	9.1.2 9.2.1	April 9
3	Shortest Distance Between Lines	3.1-3.9 3.11-3.18	8.13.1,8.14.1, 8.16.1,8.17.1	9.3.1 9.3.2	April 16
4	Line Piercing a Plane	3.20-3.23	8.20(Solve by three methods)	9.4.1	April 22
5	Intersection of Planes, Dihedral Angles of Planes	3.19 3.24-3.28	8.21.4,8.22.5	9.5.1 9.6.2	April 30
6	Line Perpendicular to a Plane	3.29-3.35	8.23.6,8.24.2, 8.25.3	9.7.2	May 7
7	Angle Between a Line and a Plane	3.36-3.39	8.26.4,8.27.3	9.8.2	May 14
8	Revolution Methods	4.1-4.13, 4.16	8.31.4,8.32.1, 8.33.2,8.33.11	9.9.3	May 21
9	Graphical Vector Analysis	5.1-5.16	8.37.1,8.38.1 8.39.6	9.10.6	May 28
10	Cylinders and Developments	6.1-6.25	8.41.2,8.42.1, 8.43.4,8.44.2	9.11.2 9.11.5	June 4
11	Intersections of Curved Surfaces	7.1-7.6	8.66.1,8.66.2	9.14.8	June 10

Textbook: Applied Descriptive Geometry, Warner and McNeary

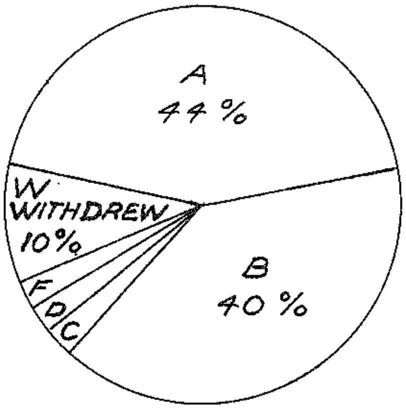
FIGURE 1 DESCRIPTIVE GEOMETRY - SPRING 1971

COURSE OUTLINE AND QUIZ SCHEDULE

the material learned to solve an actual engineering problem. This application of principles caused difficulties for some students but these were overcome with practice. In the two weeks spent preparing for the course before it began, only two quizzes for each of the first five units of material were completed.

Results

While the students were skeptical of the course at first, in the end, almost all were enthusiastic and pleased with the results. Written comments were requested at the end of the course. Typical responses were: "The best learning experience I've had at Cal Poly to date." "Being allowed to proceed at our own rate is excellent." "The pressure of examinations is removed since we were allowed to retake quizzes." Descriptive Geometry is traditionally a popular class but these comments indicate more than just normal student acceptance of the course. Student enthusiasm was also reflected in the grades they received. Figure 2 is a chart showing the distribution of letter grades for the class.

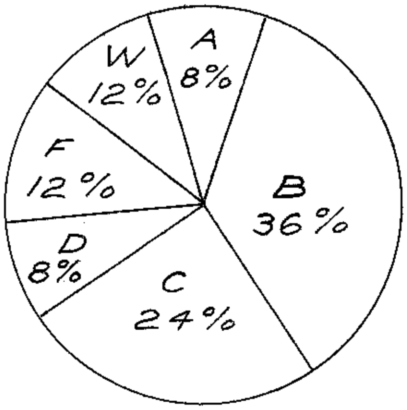


Grade Distribution
Self-Paced Course

Figure 2

The students who dropped the course in the first three weeks apparently could not accept the responsibility resulting from the freedom self-pacing allowed. Figure 3 is a chart showing similar information for a class taught by the same instructor two years earlier by conventional methods. The comparison is startling.

A majority of the students used the full eleven weeks to complete the course. There were some, however, who took full advantage of the opportunity to finish early. Others would be ahead of schedule and not work on the course for a week or two. Figure 4 shows when the students completed the course by percentages. Most students enjoyed and appreciated the freedom this class allowed.



Grade Distribution
Conventional Course

Figure 3

Conclusions

The success of this experimental class proves that innovative teaching can be accomplished with a minimum of outside support.

(Continued on the next page)

* * *

The demonstrated increase in learning and student enthusiasm more than compensated for the extra instructor effort that was required. It is this author's opinion that engineering problem courses are ideally suited for a self-pacing approach. The dedicated instructor, who believes improved student achivement is the desired result of progressive education, will seriously consider adopting the self-paced approach for appropriate courses.

(Presented at the 1971 ASEE Pacific Southwest Section Annual Meeting)

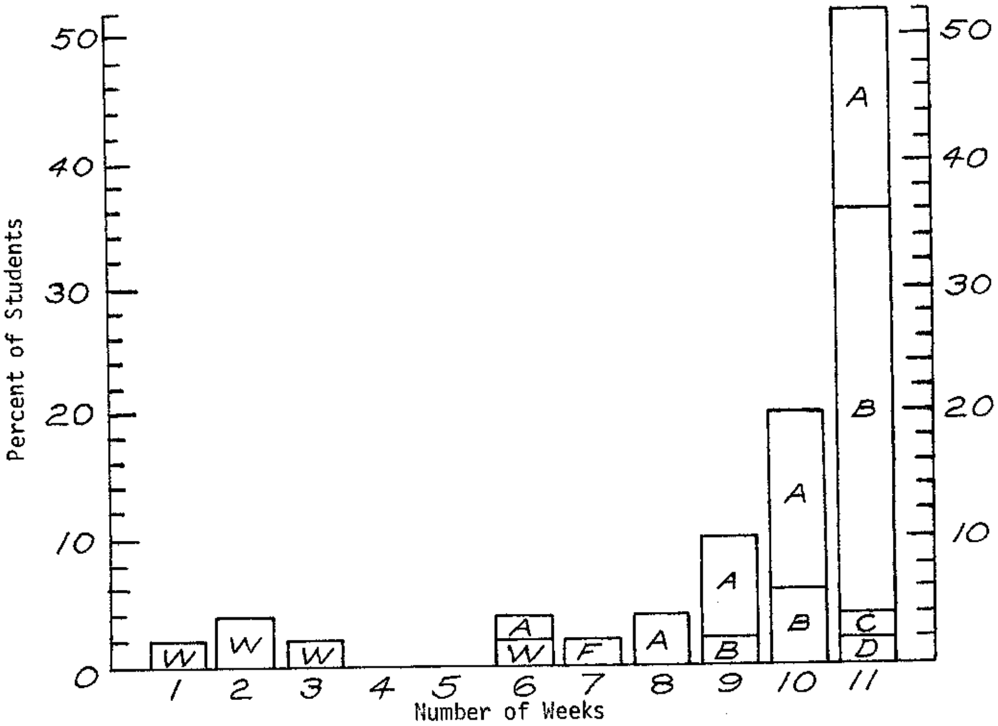


Figure 4 Completion Time Self-Paced Course

● ●

PREVIEW OF JOURNAL ARTICLES

The attached is a list of articles that have been submitted for publication in the JOURNAL. JOURNAL readers may be interested in the diversity of topics they may expect to see in this and future issues. This list is not intended to reflect an absolute publication schedule, but rather is representative of the diversity of interests of our authors. You, too, are invited to submit a paper for publication.

Human Engineering Using Off-the-Shelf Parts
Woodson
Computer-Aided Pipe Sketching
Roberts
The Role of Visualization in Creative Behavior
Faste
Automatic Drafting System Aids Bridge Design
Schuchardt
Computer Drafting - A Big Step Forward
DeNapou
Modified Self-Paced Descriptive Geometry
R. Pare'
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Measure for Measure - A Universal Standard
Laner
What is Meant by Engineering Design?
Leuba
Standards in Computer Graphics
Mochel
Utilization of Teaching Media
Sanders

STANDARDS IN COMPUTER GRAPHICS

Edward V. Mochel
University of Virginia

Standards in Computer Graphics

One of the growing pains a new field generally experiences after about a decade of development is the need for standards. As more and more people begin to work on related problems and as a greater variety of equipment becomes available, an increasing amount of information is exchanged between individuals and between groups. This is the present stage of development in the area of computer graphics.

In a recent article in Computer Graphics,[1] a plea was made for a standardization of the widely-used plotter software package. Probably the most common type of graphics output today is the plotter, and thousands of academic and industrial programs have been developed to produce plotter output. Most software is tantalizingly similar, yet there are usually difficulties if a program from one installation is run at another. The goal in this case is plotter software independent of both plotter and machine (computer).

My own particular area of interest is the rather random selection of coordinate axes and angles of rotation. These are necessary for reference when moving sets of points in three dimensional space.

It is certainly not surprising that such a wide variety of systems exist, as past experience in the field of engineering alone has produced little agreement. Figure 1 shows some examples of typical 3D coordinate axes found in engineering and related texts and journals. This figure shows the relationship of the XY plane to the Z axis. In many mathematic texts, the XY plane is horizontal with the Z axis vertical, as shown at (A). In the field of numerical control[2], several systems are in use, depending upon what type of machine will be operated by the program. A shaper, with its tool motion toward the front would have the same coordinate axes as (A), while a vertical turret lathe and a vertical milling machine would use the axes shown at (B). Applied mechanics texts frequently use the XY plane in a vertical position with the positive Z axis toward the observer as shown at (C). In flight mechanics, the direction of flight is along the X axis, with Z pointing toward the earth. The first four systems shown in figure 1 are right handed with the last system (E) being left-handed.

One factor to consider in choosing a set of axes is its relationship to the conventional multiview drawing. If we omit system (D) in figure 1 as being too specialized, the remaining four systems are shown in figure 2 as they would appear in the principal views, i. e., top, front and right side views.

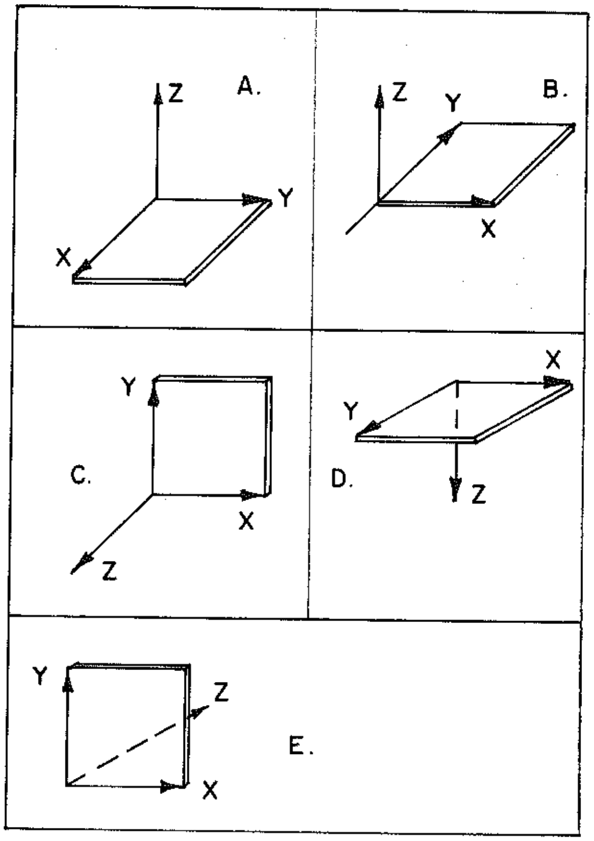

Figure 1. Five commonly-used systems of coordinate axes: (A) mathematics; (B) mechanical design; (C) mechanics; (D) aerospace; (E) other

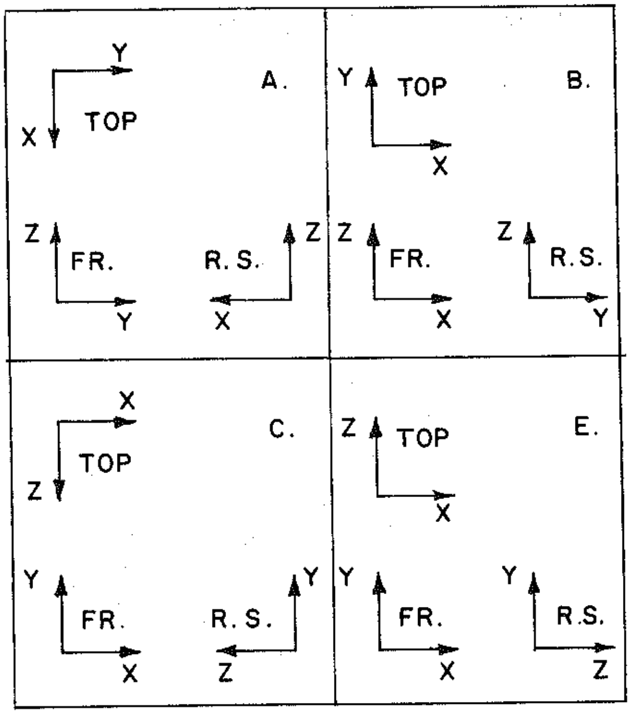

Figure 2. Four Axes Systems shown for three Principal Views: Top, Front and Right Side.

The typical output from a computer graphics calculation is fed to the plotter, two coordinates at a time, to draw the principal views. The two coordinates (X_p, Y_p) which the XY plotter uses to draw the views have the same relationship for all views, as shown in figure 3. The final conclusion from looking at figures 2 and 3 is that a system which makes 2D coordinates (Table 1) an easy, logical conversion is desirable.

Let's examine the four systems from this standpoint. The front view for systems C and E is very simple. The x coordinate in 3D space is given to the plotter as x, and the 3D y coordinate is used as y. The circled coordinates correspond exactly with the plotter information.

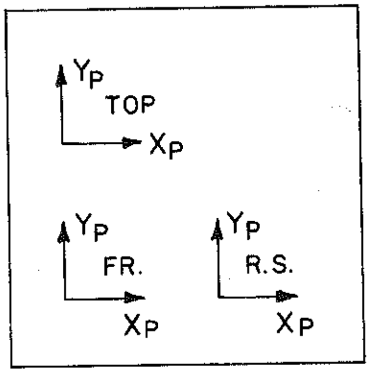

Figure 3. The Plotter Coordinates Used to Draw the Three Principal Views.

System A is the poorest of the four on this type of analysis. None of the coordinates relate directly to plotter-drawn views.

Systems B and E are slightly better than C because of the sign change C requires in both the top and right side views. Both B and E keep positive values up and to the right in all views, which corresponds to the convention XY coordinate system of the plotter.

To make the final judgment, I would personally prefer to see B chosen over E. They are both easy to use and remember, but B is right-handed while E is left-handed. In engineering systems, right-handed systems are in more common usage.

An easy way to remember this system is to remember that no conversion at all yields a top view. That is, to plot point P (x, y, z), the plotter plots a point at (x, y).

Another convention to consider for standardization is the names and senses of the three

Axis System \ View	Top	Front	Right Side	Overall Rating
A. X_p = Y_p =	y -x	y z	-x z	poor
B. X_p = Y_p =	ⓧ ⓨ	ⓧ z	y z	best
C. X_p = Y_p =	ⓧ -z	ⓧ ⓨ	-z ⓨ	good
D. X_p = Y_p =	ⓧ z	ⓧ ⓨ	z ⓨ	better

Table 1. A comparison of coordinates axes systems and the conversion necessary to draw three principal views.

angles of rotation. These are frequently used in 3D computer graphic programs to move sets of points around in space. In order to discuss this motion, we must first decide what is moving and what is stationary. For example, it is usually easier to consider the observer and the coordinate axes to be stationary, and have the object being viewed to be rotating and translating.

If a right handed system is used, the positive direction of rotation about the Z axis would be as shown in Figure 4a. This direction is clockwise as viewed from the origin looking up in the positive Z direction. However, the rotation will be counterclockwise as seen in the top view (looking down in a negative Z direction). Thus, this system would be usually described as having a positive rotation as CCW.

If the same right handed convention is followed, as shown in figure 4b, a clockwise rotation in the front view would be considered positive, and a rotation counterclockwise in the right side view would be positive. The three angles shown are borrowed from the aerospace discipline and are ψ (psi) for rotation about the z axis, θ (theta) for rotation about the y axis and ϕ (phi) for rotation about the x axis.

These rotation conventions are depicted in figure 5 as they would appear in the three conventional views.

At this particular point in time I feel the standards suggested in this article are the best possible choice. I believe most members of our Division who have given this topic consideration agree that some standardization is desirable, and in the long run will benefit everyone. However, there is not yet complete agreement as to the best choice.

Two other factors will possibly affect standards in the future. They are metrication and the choice between first and third angle projection.

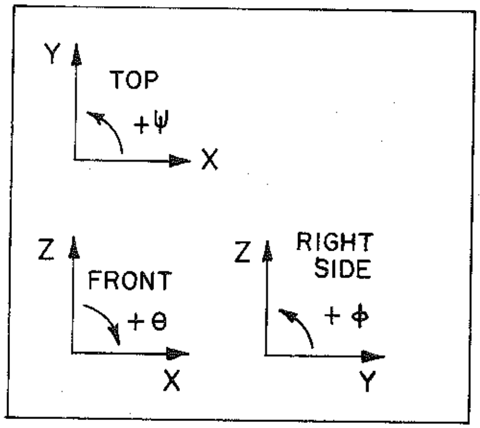

Figure 5. The conventional right-handed angles of rotation shown in the three principal views.

Of the two, a switch to metric units of millimeters for plotter coordinates will cause the lesser confusion. Probably plotters will offer the user a choice of units during an interim period, and ultimately end up with only millimeters.

The choice between European first angle projection and U. S. third angle may or may not change our conventional placement of views. If system B were to switch to first angle projection, the resulting views would be as shown in figure 6. This change, if it takes place, would not change the choice of system B as the best choice of coordinate axes. Likely either the right or left side view would be used, so both alternatives are shown in Figure 6.

It is my hope in writing this article to influence those people beginning to write programs in computer graphics to strongly consider adopting these recommendations. We will all benefit by this proposed uniformity.

1. "Graphics vs Freedom" by John P. Walsh, Computer Graphics, Vol. 6, No. 3, Winter 1972.

2. see Electronic Industries Association, EIA Standard RS-267 for more detailed explanation of machine axis and motion nomenclature.

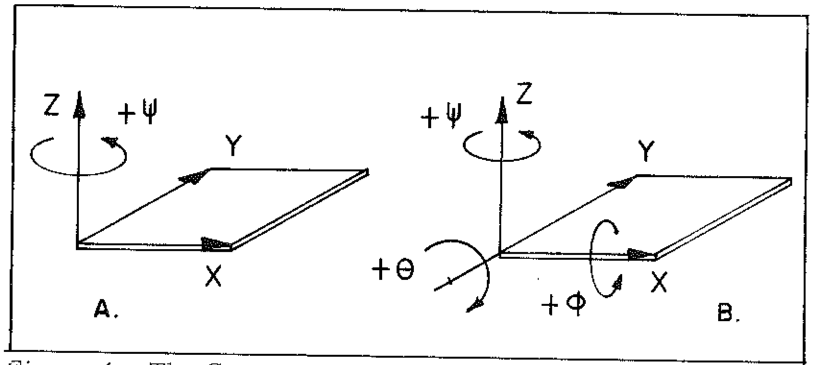

Figure 4. The Conventional Right-Handed Angles of Rotation shown in the three Prinicipal Views.

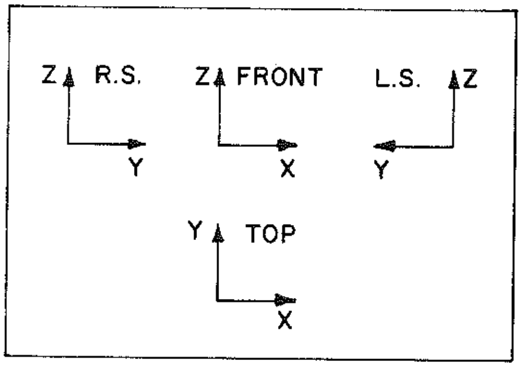

Figure 6. System B as it would appear in the First -Angle Projection used in Europe

APPLICATION OF COMPUTER GRAPHICS OF MECHANISMS TO DESIGN

George Raczkowski
Texas A&M University

At the recent ASME Mechanisms Conference (Oct. 1972) in San Francisco, it was emphasized that there is a need for computer aided design and graphics development in forms of sketching and animation which will become the kinematic development of the near future. The use of computer graphics and analysis, including animation, has a great role and importance as an efficient tool in the analysis stage of the design process. Also, in teaching mechanical engineering courses like dynamics and kinematics of mechanisms, such a program and film as described in this article proved to be very useful. It was observed that students often have difficulty with understanding the phenomena involved in studying motion of such mechanisms as linkages, cams, gears, etc. The simple fact that when velocity is zero, the acceleration does not have to be zero is misunderstood and questioned mainly due to lack of effective visual aids. A short movie showing the complete motion of a mechanism was very helpful in studying the principles of motion of linkages.

Tedious calculations and drawings are required to obtain even partial analysis of velocity, accelerations and forces of a more complex mechanism. For example, a velocity and acceleration polygons of a four bar mechanism require drawing on the average of ten or more lines for only one position of the problem involved.

Models also require time and are expensive. This could be eliminated by use of computers, plotters or other means, particularly if the procedure requires repetitious operations.

This article describes a method where an animation and a kinematic analysis of a crank and rocker (four-bar planar linkage system) was accomplished by using a computer and plotter.

A schematic drawing of such a linkage is shown on Fig. 1. Assumed known are the lengths of links 1 through 4, angle ϕ of the crank and its angular velocity. These dimensions and values were next used to calculate the positions of the coupler and rocker with respect to the reference frame chosen. This was achieved by using a subroutine position which determines angles and lengths of different links for a particular value of angle ϕ of the crank.

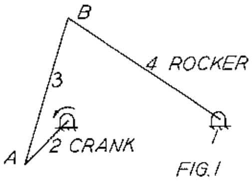

FIG. I

A FORTRAN IV program was used and executed on an IBM 360/65 computer which determined the absolute and relative velocities and accelerations in form of vectors required in drawing velocity and acceleration polygons. It also provided data for schematic drawings of the linkage system. The results were stored on a magnetic tape and used as data for a Gerber plotter to draw single pictures to be animated. A calcomp plotter could have been used as well.

The complete program contains approximately 200 punch cards which include a main program and six subroutines (see enclosure).

For every five degrees of motion to be recorded 72 drawings were required for a complete revolution of the crank equal 360°. By photographing the drawings with a simple 8 mm movie camera with capability of taking single frame pictures a movie was composed. The "smoothness" of the film or animated motion after photographing each single picture of different positions depends on the number of pictures taken and determines the range of the DO-loop in the main program. This could be of importance in requesting sufficient execution time and evaluating the cost of the film. For example, by making 360 pictures for every degree of motion of the crank or photographing each of the 72 pictures three times, it was observed that the animated motion did not differ significantly for each case.

The velocity and acceleration subroutines calculate directions and magnitudes of vectors representing velocities and accelerations for particular points of interest to the designer. The velocity subroutine solves the vector equation

$$\overrightarrow{V_B} = \overrightarrow{V_A} + \overrightarrow{V_{B/A}}$$

while the acceleration subroutine solves another vectore equation of the following form

$$A^n_B \mathbin{+\!\!\rightarrow} A^t_B = A^n_A \mathbin{+\!\!\rightarrow} A^t_A \mathbin{+\!\!\rightarrow} A^n_{B/A} \mathbin{+\!\!\rightarrow} A^t_{B/A}$$

This is the relative velocity and acceleration method which is so commonly used in analysis of mechanisms, where the vectors are resolved into normal (n-index) and tangential (t-index) components.

The vector subroutine converts the obtained results to vector quantities, while the angular subroutine calculates the magnitude of angular velocities and accelerations and determines their sign.

The computer graphics was implemented with the use of subroutine CALL PLOT (X, Y, IPEN). For an X-Y coordinate system as reference frame this subroutine will cause the pen to draw a line whenever IPEN = 2, and will move it without drawing a line to a new position of coordinates X and Y when IPEN = 3. IPEN = 99 will stop the plotter. These abscissas and ordinates determine points to be connected and represent the schematic drawing of each position of the mechanism. They also position the vectors (or their components) of velocities or accelerations.

By changing the pen number in the original program before recording on tape, colors could be used for different lines in the drawings obtained from plotter. Also, different scales could be used, including symbols, notes, arrowheads, etc.

Drawings on Fig. 2 (1-9) made by the plotter show the change of the magnitudes and directions of acceleration vector for one point of rocker. When the crank is in the horizontal position to the right as shown on Fig. 2, the length of the vector is merely one half of the length of the vector for the same point on the rocker after the crank has moved 40 degrees from its original position as shown on Fig. 2-1. Also, the direction of the vector has changed. These drawings when animated were quite impressive in particular those related to acceleration due to rapid changes from zero to maximum for limited motions of rocker which barely swings to the left and right sides of the vertical axis.

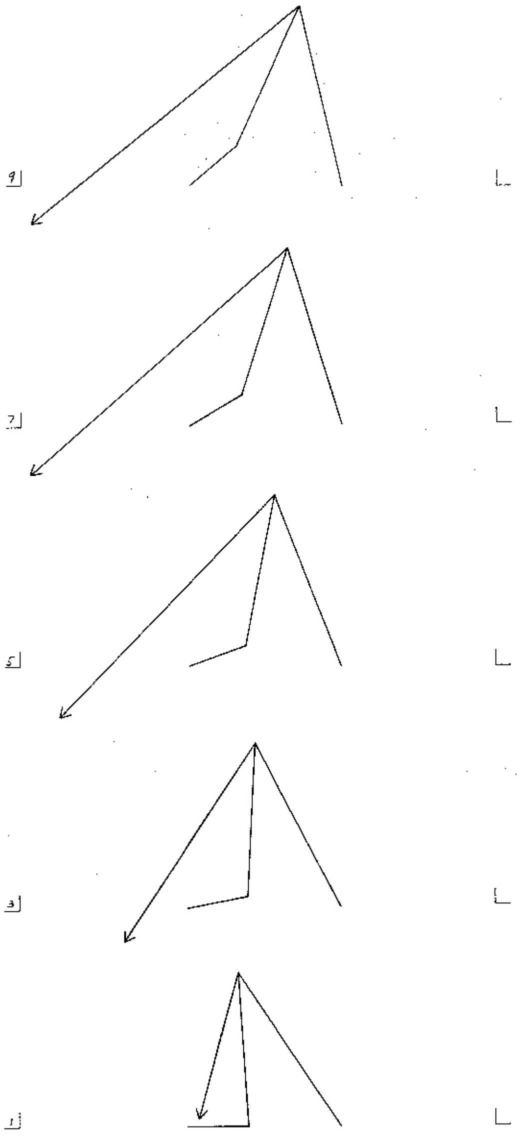

FIG. 2

Photographing was done by using a simple camera, a copy stand for holding drawings, and lamps providing proper light conditions when taking pictures as sketched and shown on Fig. 4. Important are the corner marks on each drawing which must be made by the plotter and obtained from the program.

Of interest could be a vertical plot of moving ordinates of velocities and accelerations (or separated) as functions of crank angle or time. By removing the vertical lines from such a plot, the motion of just a point representing velocity or acceleration versus time or crank angle could be shown. Such a path would appear similar to that shown on Fig. 3 and represent a complete analysis of variation of velocity and acceleration between 0 and 360°.

Next, changing certain data cards in the main program different linkages or points of interest could be studied. Single links could be animated and studied. This program could be well extended and adapted for studying motion of spatial mechanisms by implementing appropriate auxiliary views as already attempted by some.

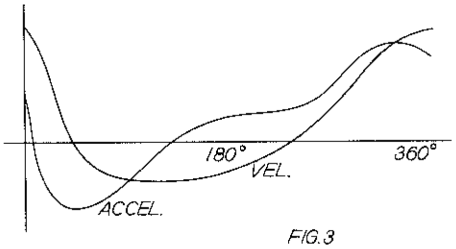

FIG.3

The time required for executing such a program is a matter of seconds, while the 72 drawings were made within a few minutes by the plotter with much higher accuracy than those made by man. The overall cost of the described film and programming did not exceed ten dollars.

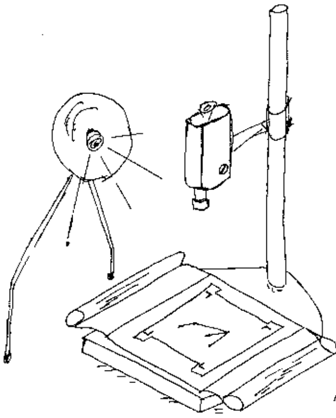

FIG. 4

PROGRAM OUTLINE

Main Program

```
.........
DIMENSION,COMMON
READ DATA (LENGTH,ANGLES,OMEGA)
WRITE DATA
FORMAT
.........
DO 111 K=1,73
CALL POSITION (CALCULATE ADDITIONAL DATA)
CALL VELOCITY (CALCULATE VELOCITIES)
CALL ACCELERATION (CALCULATE ACCELERATIONS)
WRITE
..........
CONTINUE
STOP
END
.........
.........
```

Subroutines

```
.........
SUBROUTINE VELOCITY
COMMON,DIMENSION
.........
CALL VECTOR
CALL ANGULAR
.........
CALL PLOT (O.,O.,3)
CALL PLOT (AX,AY,2 )
CALL PLOT (BX,BY,2 )
CALL PLOT (A,0., 2 )
CALL PLOT (AX,AY,3 )
CALL PLOT (VAX,VAY,2)
CALL PLOT (BX,BY, 3)
CALL PLOT (VBX,VBY,2)
CALL PLOT (0.,0.,99 )
RETURN
END
.........
.........
```

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WHAT IS MEANT BY ENGINEERING DESIGN ?

Richard J. Leuba
University of Wisconsin--Green Bay

I was an engineering designer for half a dozen years in my career, but never was I a student of the process in which I was engaged. Recently, I had occasion to write about design so I turned to several sources for a definition.

Before examining the meaning in detail, it is well to observe that design is at the focus of engineering. Krick declares that design is "... the central activity in the practice of engineering" (1969:107), while Earle calls it "... the most distinguishing responsibility that separates the engineer from the scientist and the technician" (1969: 4). Woodson reports a widespread belief that design is "... the essential, unique hallmark of the profession" (1966:vi), and Levens states simply: "design is the core of engineering" (1968:542).

My analysis which follows later, is comprised of six essences, neither of which is complete in itself, but which together orchestrate the whole. The reader will observe dissonance, meanings not necessarily compatible with each other, but such is the development of language.

Design is purposeful, and I will have something to say later about the qualification of purpose, the problem of attaching ethical concerns to a definition of design. But first, here are relevant quotations from well-known sources:

Asimow: "Engineering design is a purposeful activity directed towards the goal of fulfilling human needs, particularly those which can be met by the technological factors of our culture." Asimow continues pointing out that engineering is not the only activity bent upon satisfying these human needs. p. 1

Beakley: "... the process by which engineers bring into being technical devices, services, and systems for the use and benefit of mankind is the engineering design process." p. 445

The engineering design process "... is a creative and iterative process of problem solving which is used by the engineer as a means of achieving his objective." p. 445

A design is "... a bridge... between the resources available and the needs of mankind." p. 445

Earle: "The act of devising a solution to a problem by a combination of principles, resources, and products is design." "... the design of a product is the most distinguishing responsibility that separates the engineer from the scientist and the technician." p. 4

Harrisberger: "When there is a physical problem to be solved, it can be reduced to what is available and what needs to be done, i. e., an input and an output. In between these two situations, a physical device, machine, or process must be installed to convert the available input into the required output. Filling this 'space,' this 'black box,' with a specifically designed system of hardware is 'blackboxmanship.' This is engineering design, and it has many facets." p. 2 (Harrisberger's definition confuses me: is the "input" of which he speaks, for example, a rotating shaft which then in the process of design is converted by an electrical engineer to alternating current, or does Harrisberger mean by "input" the resources available to the designer, or finally, does he mean that the "input" is the problem itself?)

Hill: "Engineering design is a continuous process whereby scientific and technological information is used to innovate a system, device, or process that will benefit society in some way." p. 33

"Design is regarded as the process of selectively applying the total spectrum of science and technology to the attainment of an end result which serves a valuable purpose." --R. J. McCrory, quoted by Hill, p. 33.

Knoblock: "The job of the design embraces the activities and events that transpire between the recognition of a problem and the specification of a functional, economical, and otherwise satisfactory solution of that problem."

"Design is the general process by which the engineer applies his knowledge, skills, and point of view in the creation of devices, structures, and processes."

Design is "... therefore, the central activity in the practice of engineering." p. 107

Levens: "Design is the core of Engineering. In a broad sense design includes circuits, machines, structures, processes, and combinations of these components into systems and plants." "Design is a conceptual process which is done largely in the mind..." p. 542

Middendorf: "Engineering design is the activity wherein various techniques and scientific principles are employed to make decisions regarding the selection of materials and the placement of these materials to form a system or device which satisfies a set of specified and implied requirements." p. 2

Wellman: Engineering design "... is the process of creating, originating, or inventing a plan, a scheme, or a device." It is "... the recombination of known elements into a new or different arrangement." "... design is therefore primarily a process of synthesis." p. 373

From these quotations, I extract below several essences of the meaning of engineering design. Each inset is my own edited adaptation of the original, and the authors (given for reference only) are not responsible for whatever mistreatments I may have rendered in my search for the essential.

Engineering design is...

*... a purposeful activity:

Engineering design is a purposeful activity directed towards the goal of fulfilling human needs. (Asimow)

Engineering design satisfies a set of specified and implied requirements. (Middendorf)

*... connective:

A design is a bridge between the resources available and the needs of mankind. (Beakley)

Engineering design is an accomplishment bridging a defined problem with a specified objective. (RJL)

*... a synthesis:

Engineering design is the recombination of known elements into a new arrangement. (Wellman)

*... a process:

Engineering design is the process of bringing into being technical devices, services, and systems for the use and benefit of mankind. (Beakley)

Design is a process embracing the activities and events that transpire between the recognition of a problem and the specification of a functional, economical, and otherwise satisfactory solution to that problem. (Krick)

*... the central and distinguishing mark of engineering.

Design is the central activity in the practice of engineering. (Krick)

Design is the most distinguishing responsibility that separates the engineer from the scientist and the technician. (Earle)

*... not the substance, but the conception.

Design is a conceptual process which is largely done in the mind. (Levens)

Engineering design is activity in which techniques and scientific principles are employed to make decisions. (Middendorf)

The design engineer puts known concepts, processes, or devices into a unique arrangement which can then be produced or implemented. (Knoblock)

Engineering design is the process of creating a plan or scheme. (Wellman)

Discussion: Admiring a new music hall, we might say "This is an excellent design," but it is not the building which is the design, but rather the concept of the building. Before the building is constructed, we might say, "These plans and specifications are an excellent design," but the plans and specifications are only the symbolic representation of the design. The plans communicate the design to us, and the finished building even more so, but neither is the design. "Design is a conceptual process which is largely done in the mind."

As seen in the foregoing list of six essences of engineering design, there is evidence -- to use the language of thermodynamics -- of both process and state point. In thermodynamic analysis, process quantities (heat and work) are scrupulously separated from state point quantities (temperature, entropy, etc.). To confuse process with state point in thermodynamics is as much an error as confusing a profit-and-loss statement with a balance sheet in business. In engineering design, however, a dual meaning has taken hold and rooted, so one needs to make clear whether one is engaged in design (process) or whether one has produced a design (state point).

A qualification of design which I do not single out as an essence is the value of design to mankind. Beakley speaks of the "benefit of mankind," and Hill of the "benefit [to] society". The intentions are well-meaning, but the emphasis appears in the wrong place. Design is not defined by whether or not it "benefits" mankind. Design is too far down the road to introduce ethical considerations. We all can think of engineering designs which we would agree are beneficial, and of others we would regard (or perhaps disagree on) which are decidedly not beneficial.

Man's relationship to man, and more specifically an engineer's relationship to other men is basic. It deserves more recognition than to be tacked onto a definition of an aspect-- albeit a major one-- of the engineer's work. In fact, social responsibility is more fundamental and more pervading than the engineer's job in all of its dimensions. Social responsibility is as large as life itself and involves man's relation to both present-day society and to society at any time in the future. It applies to the engineer's total experience, including among other things his work as an engineer, which in turn includes design responsibilities. This may be illustrated with an analogy.

In computer design the concept of reliability does not arise because a component (a capacitor, say) needs to be reliable, but rather it arises because reliability is fundamental to the entire computer. Reliability as a concept does not originate with a computer component but rather with the whole system, and similarly, ethics in engineering originates not with definitions of design but rather ethics originates with the engineer as a person.

In summary, engineering design is purposeful, connective, and conceptual. It is a synthesis, a process and the central and distinguishing feature of engineering practice. Sometimes engineering design refers to an activity (process) while at other times it means a conclusion (state point). Through a deep sense of commitment to the highest ideals in human relationships, does the engineer conduct his life, his work, and his choice of and action with various engineering designs.

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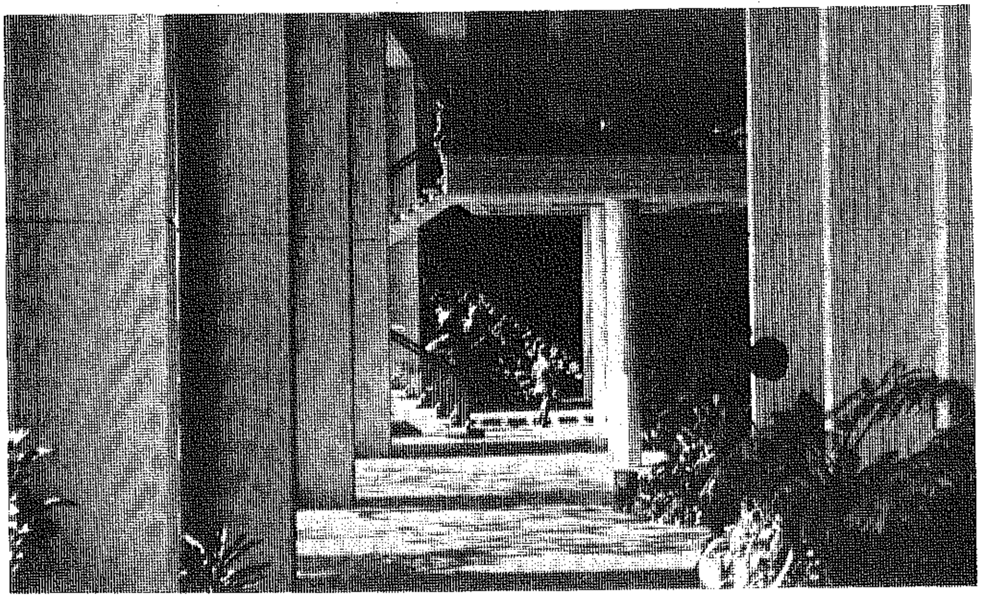

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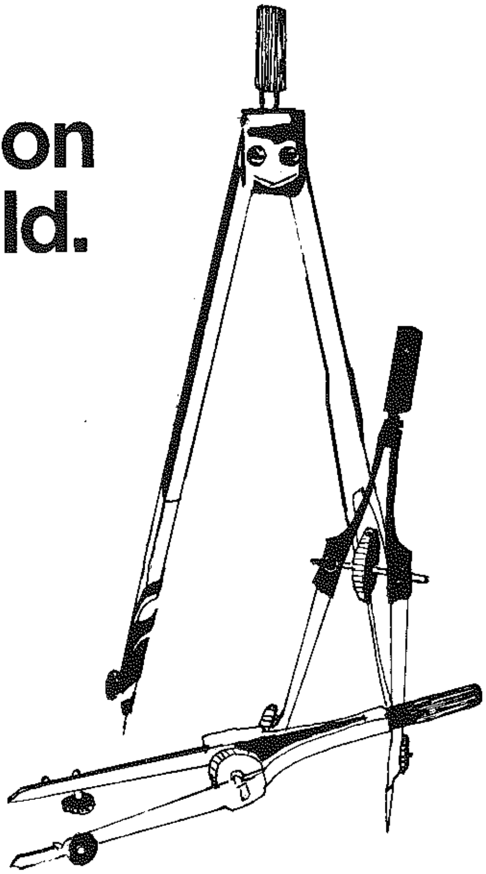

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FRESHMAN GRAPHICS INVOLVING THE COMPUTER

F. A. Mosillo
University of Illinois at Chicago Circle

BACKGROUND

At the start of the Winter Quarter, 1972, the College of Engineering at the University of Illinois at Chicago Circle began to implement a revised version of its undergraduate core curriculum. One of these revisions was to change the emphasis of the graphics course from that of design to graphical methods, which includes topics in Engineering Drawing, Graphs and Equations, and Graphics and the Computer.

The course consists of two, two-hour laboratory-discussion periods per week for a credit of two quarter hours. Recent changing trends in graphics and engineering have been extensive, and although the areas of Engineering Drawing and Graphical Mathematics have been taught on this campus in various ways over the last several years, this is the first time on our campus that first quarter freshmen students have become involved with the computer. Most computer graphics courses offered elsewhere are taught at an upper level, and it is usually assumed that the students have previous knowledge of computer programming. This course, being a first quarter freshman course, cannot and does not assume such a background.

COURSE CONTENT AND STRUCTURE

The three subject areas in this new graphics course, Engineering Drawing, Graphs and Equations, and Graphics and the Computer, could only be taught with any degree of satisfaction (in such a short period of time as ten weeks) if the three areas were presented in a tightly interrelated manner. Some of the faculty teaching this course have achieved such an interrelationship by using computer graphics as an integrator of the other two areas. For example, while studying the Engineering Drawing area, students are given assignments to prepare orthographic sketches of elements of the computer facility. Graph and Equation assignments are integrated into computer problems studied later in the course. To give an example of how the course might be structured, a sample schedule of the daily topics is outlined on the facing page.

Without a careful selection of problems that can be used in more than one area, this schedule could become a mass of fragmented material. Note that the problems assigned on day 2 (Graphs and Flow Models) can be utilized again on day 4 and/or 7 (Empirical Equations) and again on day 8 (Computer Program Presentation of Empirical Data). Note also that staggering the areas not only allows them to be integrated, but even more important it allows for the INCUBATION period so necessary in the learning process. This is especially needed while studying Empirical Equations to allow time to grade and return the problems and time for the students to review and understand their errors. Only then are the students ready for the next step.

GRAPHS AND EQUATIONS FIRST?

To implement the principle that one must teach from something in the students' background and develop this into the new material, one must reevaluate the background of today's incoming freshmen. In the past, the majority of students have had some form of engineering drawing when entering the Colleges of Engineering. This is not true today. Therefore, the base upon which we must teach our graphics courses must be different. For this reason, graphs and graphical mathematics have been chosen as the introductory material. The emphasis on empirical equations is due to the ease in which it can be related to computer computations and also the need for this area in the subsequent engineering courses at Circle Campus. One thing is certain about every student that enters Engineering, they all have some mathematical background. It may also be assumed that they have seen graphs and diagrams before, but few have seen a multiview drawing.

The initial problems must be based upon the student's experience and hopefully serve several ends. Although the primary objective is to introduce them to the academic material,

Day	Daily Topics	Hours in Areas		
		GE	GC	ED
1	Introduction - Course Structure & Content	1/2	1/4	1 1/4
2	Graphs & Flow Models	2		
3	Hour Test & Discussion of Computer Facility Operation	1	1	
4	Graphs & Empirical Equations	2		
5	The Elements of Computer Programming		2	
6	Sketching*			2
7	Graphs - Power & Exponential Empirical Equations	2		
8	Hour Test & Presentation of Empirical Equation Development Program	1	1	
9	Pictorial Drawing*			2
10	Multiview Drawing*			2
11	Engineering Applications	1		1
12	Working Drawings			2
13	Detail Drawings			2
14	Sections & Conventions			2
15	Hour Test & Discussion of Technical Reporting	1/4	1/4	1 1/2
16	Auxiliary Views			2
17	Computer Development of Engineering Drawings		1	1
18	Working Drawings**			2
19	Working Drawings**			2
20	Two Hour Test	1/4	1/2	1 1/4
	Class Hours	10	6	24
		25%	15%	60%

GE - Graphs & Equations
GC - Graphics & the Computer
ED - Engineering Drawing (instrument drawings, by necessity, are omitted from this course)

*Objects to be drawn are selected from the computer facility where possible.
**Computer aided where feasible.

• • •

the assignments can also serve to orient the student regarding 1) scheduling, 2) the curriculum, 3) the campus, and 4) the computer facility. This can be accomplished with graphs and diagrams. Here the students (1) study and graph their weekly activities, (2) develop a flow diagram of their curriculum, and (3) prepare maps of their campus or computer facility, as well as flow diagrams of the administration process, registration, etc.

These tactics may not be unique, but do involve the students in their campus and in its programs and structure, while also setting the stage for coming assignments. Both are done with the maximum utilization of the student's current knowledge and with the least loss of time to the graphics areas.

GRAPHICS AND THE COMPUTER

Present indications show that a greater knowledge of graphics results by the introduction of the computer because the students become highly motivated. Unfortunately for our "teacher ego", this is true in spite of how good or bad the teacher is; i. e. computer involvement has the inherent characteristic of "turning on" the student. It is up to us to tap this source of motivation to better teach our discipline.

The daily topic outline should give the reader both an overview of the course content and the order in which the material is to be presented. Notice that although the course outline allows approximately 15% (6 hours) for Graphics and the Computer, actually more involvement is achieved without loss to the other areas. This is as previously stated, because many of the assignments in the other areas are using computer facility elements as a basis for learning. An example of this is to have the students develop a flow diagram of the computer facility interactions during the graph and diagram time. This is similar to the development of a flow diagram of a student's curriculum which in both cases satisfies two needs, that of making flow diagrams and that of introducing the student to material that will be useful to him at a later date. This adds a personal self-interest factor to the material being studied.

Another instance in the use of graphics is when the student sketches the card punch machine. Here we involve the student in lettering, sketching, orthographic projection, and pictorials. In laying out the keyboard of the card punch machine, the student learns to sketch as well as letter, and becomes aware as to how this keyboard differs from other keyboards. He is also to develop a flow diagram of this keyboard indicating the operations for punching cards. Here again, the student is not only learning how to make a flow diagram, but also how to operate the card punch machine. The sketching of an orthographic and pictorial of this machine also serves to identify the machine and how one would go about describing it in an engineering language way. Note that none of this material is charged to the computer graphics allocation and thus there should be no conflict of interest between the engineering drawing advocate and the computer graphics advocate. Both areas are being covered as prescribed by the official course outline without increasing the work for the student.

ENGINEERING DRAWING

As shown on the schedule, 60 percent of the course is set aside for engineering drawing. Sixty percent of a two quarter hour course is a far cry from the 30 weeks that the engineering students were exposed to in the past. There will be no attempt here to justify or refute the amount of graphics in the curriculum today or in the past. The viewpoint here is "this is what we have and how do we make the best of it." As stated previously, all the work in the engineering drawing area is to be sketched. The only "instruments" used in this course are straight edges for the graphs and the computer in its presentations from a computer operated plotter.

The initial engineering drawings are made using the card punch and the users portion of the computer facility as models to teach multiview and pictorial drawing. Although some might feel that these are much too complicated for beginning problems, this does not seem to be true in class, as the students do no poorer in drawing three views of a complicated machine than they do in drawing 3 views of a cut up block. Of course, it is not a perfect assembly drawing of a machine and it would possibly offend many traditional graphics teachers. However, we must look at what we are trying to accomplish, and it is not accomplished draftsmen but engineers who are able to read and sketch engineering drawings.

SUPPORT PUBLICATIONS

The standard graphics texts have become so all-inclusive that, in the author's opinion, they are likely to be priced out of the market, especially in courses such as this which have a limited time to present course material. As a result of the cost of the engineering graphics texts and their limitation in the computer graphics area, it was necessary to supplement the texts by specially prepared handouts. As a result, the handouts have become more substantial than the reading that was required from the texts. Since any good engineering drawing text (whether it is a current or past edition) would suffice in the engineering drawing area, a table of the major texts was prepared listing recommended readings of the various topics covered. The combination of the handouts and the table have made it unnecessary to require any specific text for the course. To expedite and individualize the material being presented to the students, a collection of problems coupled with the handouts, and the recommended reading table, will replace the standard use of a workbook and a text.

CONCLUSIONS

Customary portions of computer graphics, such as graphic displays of multiviews and computer aided design on cathode ray tubes, are presented by movies as well as by demonstrations within the computer facility. The course succeeds in introducing the students to types of problems, software, and hardware that are available in the computer graphics area and the resultant visual outputs. It is hoped that this introduction will encourage some of the students to become more aware of the entire field of Computer Graphics and to consider further study and research in the area.

The future of this course looks quite promising. The students seem to be motivated in traditional graphics when graphics is related to the computer. Future installation of TV monitors in each graphics classroom will enable the instructor to contact the computer by a remote control terminal and display images in the classroom. This two quarter credit hour course is not expected to teach the student how to program; its purpose is to introduce and motivate students in the area of graphical methods. If this introductory course proves to be successful, demand for more advanced courses in the area can be anticipated and such courses are expected to be planned and offered.

SLIDE RULE COURSE ON TV:

GAINS CLARITY AND FLEXIBILITY

T. C. Sarchet
Ohio University

The conscientious teacher is eager to assist in speeding the student on his way toward the acquisition of desirable knowledge, concepts, attitudes and skills. This striving teacher, in having a hand in setting up the learning environment, is driven to ensure that the routes of communication--so often hearing and seeing--are based on the best possible conditions. Good teaching cannot allow these communication routes to earn the designation of being "primitive" or "conditionally passable" lest the student be motivated to turn off. A successful teacher--even after years of experience--is unrelenting in his search for improved materials, devices or techniques which will allow him to construct routes of communication possessed of "super highway" quality.

A Case in Question

During the last ten years at Ohio University, the writer has had the opportunity of working with approximately 2,000 students in a course titled Slide Rule Operations. This course is a one hour credit course required of persons doing the work for the degree in Industrial Technology and is taken as an elective by students from many other areas. Completion of the course allows the student to gain skill in the use of some 22 scales on a modern deci-trig log-log slide rule.

In the endeavor to present to the student the operations required to solve various type problems, a number of approaches involving visual communication have been employed. During some quarters--in lessons one, two and three--a seven foot model slide rule mounted on the blackboard at the front of the classroom, was used by the instructor to show each setting and reading on the scales. During the remaining lessons, in which the student and instructor each had a 10" rule in their hands, the instructor "talked" the student through each reading and setting of the problem solving procedure. During another quarter a commercially prepared transparent slide rule, designed to be used with an overhead projector, was employed for visual display but seemed to the user to be less effective than the seven foot model slide rule used at the front of the classroom. In recent quarters, the instructor has settled into using the seven foot model for each and every lesson because seemingly with rather continuous display for all steps illustrated during the course, the student was provided constantly with an available visual check on the progress of his own work and the moderating effect of the "big" rule on the instructor's tendency to go too fast was helpful in achieving better results. And yet the haunting idea persisted that there might some day be a way of obtaining greater visual clarity for the student at the back of the classroom.

Opportunity for Improving Conditions Seized

During the summer of 1971 an opportunity was presented for trying a very different approach in this course. With a relatively new television building on campus, Laurence Stone, director of Instructional Television, eagerly seeking a suitable summer project, a suggestion from Menno Diliberto, chairman of Engineering Graphics, that the course Slide Rule Operations was an apt candidate for such a project--and a promise that each setting and reading on the scales could be magnified by TV for greater visual clarity--arrangements were made for the writer to prepare materials and participate as the instructor in nine, forty minute video-taped lessons.

In initial planning, it was felt that the basic shooting technique would involve the use of the 10" rule with shots being made over the shoulder of the instructor to give the student the view as he himself would see the rule in doing the operations. However, preliminary experimentation with the cameras proved that zooming into the figures on this rule did not yield satisfactory clarity. Work with a 20" rule also provided disappointing results. A compromise between the 10" rule and the seven foot rule was resorted to in the form of a four foot rule and this last approach provided the promised results. Not only was a high degree of clarity for figures and graduation marks on the scales now available, but by use of a special effects generator, a high intensity circular area of light was used in conjunction with the pointing finger to highlight the particular location of each value set to and read.

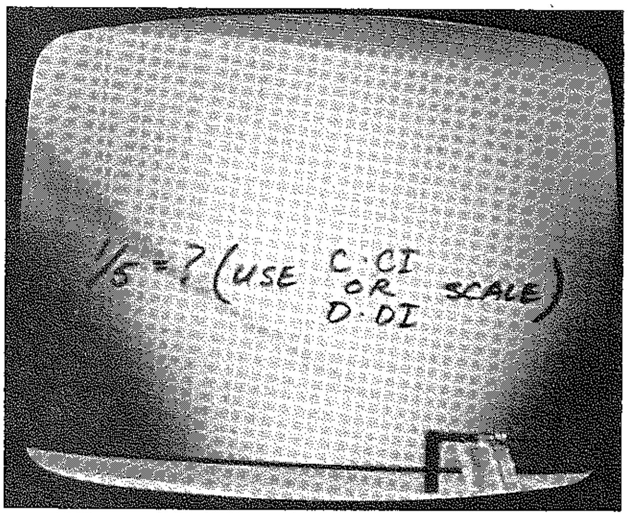


Figure 1 - Monitor display of problems on rear-view projection screen

The general pattern of visual display used for each lesson was as is described in the following. During the lesson presentation, the problem to be solved was displayed by means of a rear view projection screen and was shown clearly on the monitor as illustrated in Figure 1. It was suggested to students, in the case of long problems, that they jot down the problem. There was an attempt in the pacing of the instruction to allow time for this paper work. Cameras were then zoomed in, to clearly show the sequence of operations and readings as they were being made and explained. Figure 2 illustrates visual clarity of monitor readings of the scales. A problem of a very similar type was next displayed on the screen and assigned to the student to check his understanding and grasp with a reasonable pause allowed for him to do this problem. A follow-up on this assigned problem was then made by the instructor illustrating how the problem should have been done and with the correct answer being indicated. The small amount of pencil work required to determine decimal point location was illustrated by the instructor making use of a newspaper print pad and felt tip marker to ensure large figures and yielded very satisfactory results on the monitor as illustrated in Figure 3.

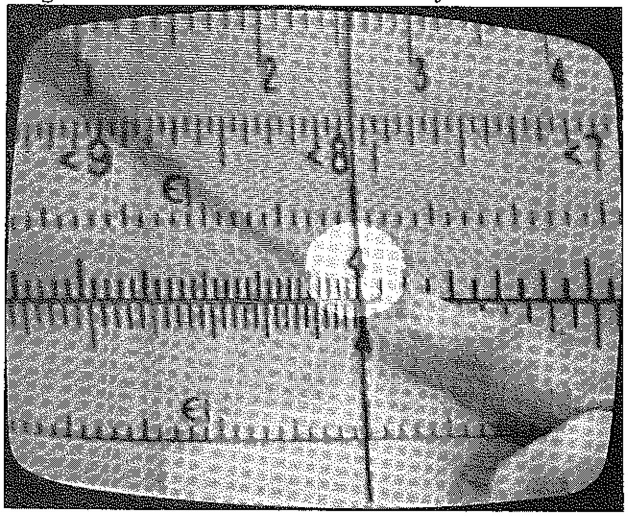


Figure 2 - Monitor display of scale reading

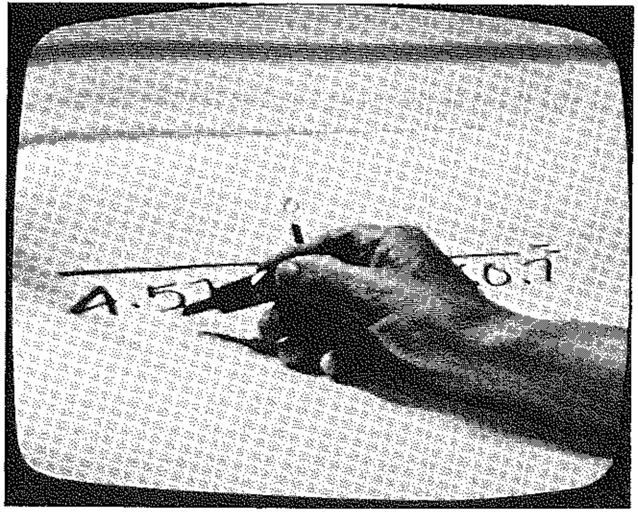


Figure 3 - Monitor display of newspaper print pad

The Application

The video-taped lessons were completed in August and were used for campus classes during the Winter and Spring quarters of 71-72. With a number of monitors located in various buildings on the campus and with the viewings of the lesson being shown twice a day, five days of the week, the student during these quarters was allowed the option of viewing the lesson any one of the ten times the lesson for the particular week was presented. Also, the opportunity was available to the student to view the lesson more than once if he felt the need to do so. Since attendance at viewings was not compulsory, the student was advised--although this practice was not encouraged--that he might forego the viewings and rely on the suggested manual for the course in dealing with each unit. In previous quarters the student who enrolled for Slide Rule Operations, scheduled slide rule class for one particular hour during the week in one particular classroom and therefore had no options in regard to place and time of class attendance.

One of the criticisms often leveled at television instruction is that "it isn't live instruction." In the orientation for this course, attention of the student was emphatically directed to the fact that the student had the opportunity for live instruction in that an instructor was available for individual help at the same hours as viewings were being shown. Students were urged to write down any questions they had during viewings they attended.

Although no formal record of class attendance was kept, the student was held accountable for units dealt with in the new approach. Requirements of the course stipulated that the student must report to an assigned room for a 15 minute, ten problem quiz on the lesson which was shown in the previous week. Here again however, the student was permitted an option by being allowed to take the quiz during any one of the ten scheduled viewing hours. The grade for the course was determined from the average score on the nine quizzes with the alternative available to the student of taking a fifty problem, 60 minute comprehensive final exam if he had less than an A and was desirous of trying to raise his grade.

Some Apparent Reactions and Conclusions

The responses to an unsigned student evaluation questionnaire administered at the close of the quarters when the course was presented by TV, plus informal comments from students provide a base for indicating some general reactions and the worthwhileness of this approach. In the interest of brevity, which at times inadvertently abets interest, only some of the statements contained in the questionnaire are included in the table which follows. Numerical readings in the table indicate the percentage of affirmative responses to that particular part of the question.

Question	Response (%)
1. Did you feel readings on the scales were	
a. Always clearly visible	53
b. Clearly visible most of the time	38
c. Often not clear	9
2. Do you think that getting lessons by TV provided a more relaxed atmosphere than would have existed with live instruction?	
a. Very much so	40
b. Somewhat	27
c. No difference	33
3. Would you recommend this course to another student?	
a. Yes	65
b. Perhaps	29
c. No	6
4. Did you usually take the quizzes on	
a. Monday	6
b. Tuesday	9
c. Wednesday	13
d. Thursday	25
e. Friday	47
5. Was the pace of presenting operational steps	
a. About right	70
b. Too fast	29
c. Too slow	1

Table 1 Results of a Student Questionnaire

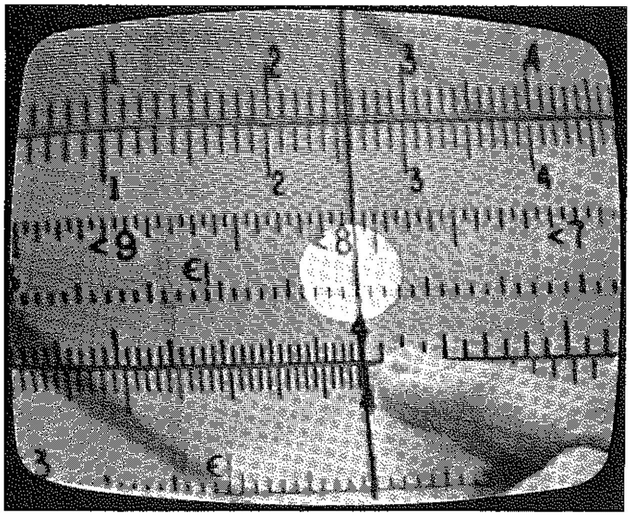


Figure 4 - Monitor display of scale reading

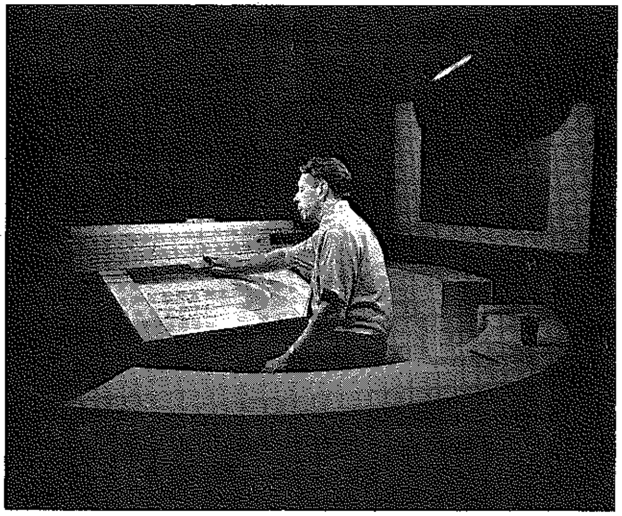


Figure 5 - Instructor and equipment used, displayed on monitor

Many questionnaires cannot and should not be taken at face value. Students asked to fill out a questionnaire just prior to finals, a time of urgency and heavy demands, may "fill" out the questionnaire rather indifferently and quickly as a matter of expediency. The original arrangements under which the video-tape series were to be made, relegated to the instructor the right to a revision of the series at the end of three years of usage. The responses to question no. 1 in the table tend to indicate that there is room for improvement in the area of visual display. There is here, however, the possibility that the student did not take care to tune the monitor properly. In question no. 4, it is quite marked that as the week progresses, perhaps procrastination has entered the picture. Question no. 5 involves a matter which was of prime concern to the instructor in preparing the series--pacing instruction for a group, unless it is purely homogeneous, obviously demands some sort of compromise. What is too fast for one person may be too slow for somebody else. Pacing the instruction a little more slowly may be a matter needing further attention in a future revision. Responses to other parts of the questionnaire indicated that the large majority of students viewed all lessons at least once rather than relying solely on the manual and made use of the option of live instruction or individual help to only a rather limited extent.

Informal comment from students indicated that one of the features of the course which appealed to them the most was the option of being able to attend class at any one of several times.

The writer believes that through the use of lessons on video tape, made in cooperation with Ohio University Telecommunications Center, a clarity of visual display that did not previously exist in this course was not realized. Course presentation via TV also made convenient a policy of flexibility in class attendance which alleviated problems surrounding sickness and other emergency type situations and thereby contributed to a less rigid learning environment.

TWO DEVICES TO AID IN SPINAL ANALYSIS

L. Duane Ball
University of Colorado

Introduction

In developing the curriculum for Engineering Design and Economic Evaluation - EDEE - the Senior Project course was envisioned by this faculty as a means of introducing students to activities pursued by many professional engineers. Problems encountered would ideally incorporate facets from many different courses in college, would challenge the imagination of the student, would involve him (or her) closely with at least two faculty members, and should be originated by the student.

Each year in May a final oral presentation of each senior project is made before an audience of faculty, students, and engineers and managers from industry. Students have often commented - a year or more after the event - that this presentation was one of the most valuable experiences of their education.

The final outcome of most projects is rarely what the student anticipated when he chose his project in the fall. Oral reports are full of surprises, even for the principal faculty advisor. Success of a project is not measured by the fabrication of a workable prototype device, but by the ways in which the student grows toward his profession through his project.

The projects which this paper describes were suggested by two doctors of chiropractic as being particularly relevant to their work. Current activity in bioengineering heightened student interest in the problems.

Project No. 1 - A device for sensing electrical activity in the spinal region

From his first conversations with the doctors the student was persuaded that he knew exactly what he was to do and even how his device would be used in the healing arts. As is so often the case, the solution preceded the problem definition. His faculty advisors strove to set this student's focus on describing what he wanted to measure and how he might try to measure it, then in modeling some of the many variables he was likely to identify in his investigation.

He established a distance of 3/4" on either side of the spine centerline as the spacing of his two contact points. Then he decided to measure the variation of resistance between these lines as the contact points were moved slowly up or down the back of the subject. Because the results of his initial application were far from being predictable he applied the probes to a piece of beefsteak. He tried AC and DC sources impressing a wide range of voltages across the probes until the steak looked most abused. At best the results were inconclusive and he turned his attention to the arms of live subjects. Again the tests yielded little information and no pattern was observed to be repeated.

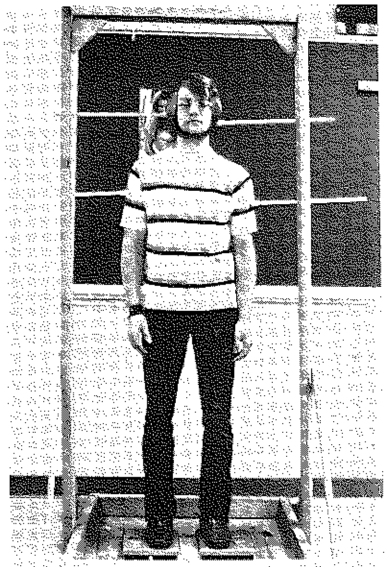
His next attempt was to try to measure voltage differences along this same path. From his earlier experience he wisely decided to use a 9 volt battery as his power source eliminating the danger of injuring any subjects. After many frustrations in building the probes and an electronic device to put the signals into a recorder he achieved positive results. First he found that the slightest variation in surface pressure between probe and skin had a large effect on his output signal. Using EKG paste reduced these fluctuations, yet careful tracing down a subject's spine at intervals of 5 or 10 minutes yielded quite different patterns of voltage difference. At the end of the year he had few unshakable conclusions to offer in his final presentation.

Project No. 2 - A device for determining how a subject's weight is distributed on his feet

Though his faculty advisor (the author) accepted the title of "bilateral scale" this project became known to all and sundry as the "two foot scale". Had the student's imagination been as great in setting down the parameters of the problem, he might have achieved glorious heights ere the year's end. Early attempts to encourage identification of parameters involved in weighing human subjects were fruitless. However, the student was finally persuaded to weigh available subjects - mostly other students - first on a six foot long beam supported on two bathroom scales. He was able to locate the subject's center of gravity along the beam, yet its eccentricity from the marked center of the beam was so small that it was not analytically useful. He was eager to try a pair of platforms supported by hydraulic cylinders. Working with a previously constructed model of this scheme, he quickly discovered that a slight eccentricity in force application caused the pistons to bind until the seal forces were suddenly overcome. The unexpected nature of these displacements, the slow response of a piston under load, and the high cost of more dependable hydraulic components were factors which discouraged further work on this model.

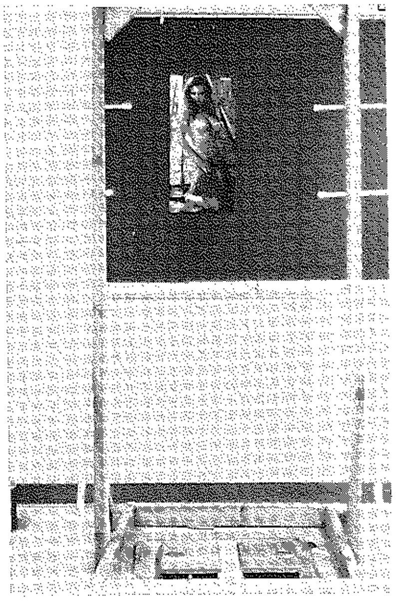
1. Subject standing normally on two scales

The next step was to discover the reasons why two comparable bathroom scales might or might not provide an accurate, repeatable weight distribution. Here the man-machine system finally surfaced. Initially the subject stepped onto the scales and two observers read his weight simultaneously. When the student observed that fluctuation in both scales continued all the while the subject stood on them, the author suggested some constraints which should be tested for their influence. The scales were placed only a few inches away from a wall the subject faced. The wall was too close for most subjects -- it apparently encroached on their circles of intimacy. Other positions were tried. The subject faced into a 30 foot deep room; he looked at a target 30 feet away; he let his gaze wander; he stood stiffly at attention; one scale was elevated as much as 2 inches above the other; a frame with dowels at hip and shoulder levels forced him to repeat his position; and he was asked to step up on the scales with his right foot first, then left foot first, then normally for as many as 25 repetitions. The investigator soon discovered that when he entered the department lounge all occupants hurriedly left. Friends avoided him. Familiar faces disappeared around corners when he spoke in greeting and so he concluded that a thorough statistical analysis of the data on hand was preferable to his becoming an untouchable socially.



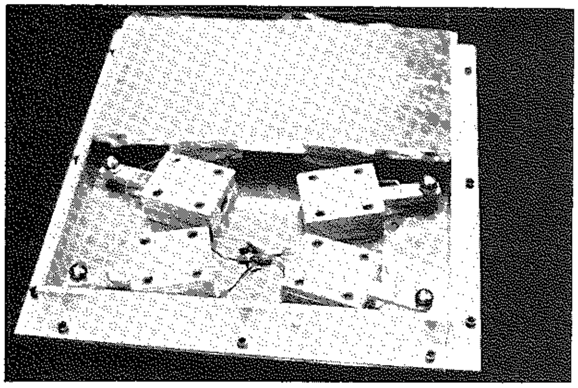
2. Frame used to place subject in repeatable position

Among other findings he concluded that the most nearly repeatable data sets were taken when a visual target - Miss November of magazine centerfold fame - was placed about 3 feet in front of the subject. A difference in scale height of 1/4 inch made little difference in weight distribution. Some subjects adapted to a 1 inch difference with in-



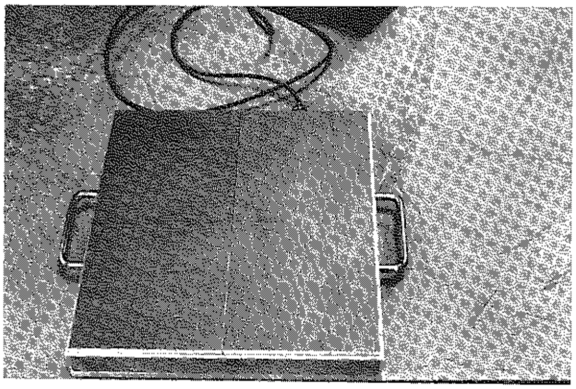
3. Frame, scales, and eye-catching target

significant weight shifts. If the feet were too close together or too far apart, wide variations occurred. Fatigue due to repeated weighings was an inhibiting factor. The weight shift over time could not be observed with this modeling scheme but was considered in a later model designed by the author. The impressive display of statistical analysis at the final oral presentation drew attention away from many unexplored parameters of this project, and in the end it was praised by many (if not the author) for its scope and conclusions.



4. First model bilateral scale

The author as a follow-up to this project designed and built a working bilateral scale. The platforms were supported by short cantilever beams whose strains were measured by electrical strain gages. A redesigned scale built in the same lines but involving greater electrical response is now being evaluated by one of the doctors who suggested the project. The speed of response, compactness of the scale, and insensitivity to operator error have yielded favorable response to data from the users. Whether a direct correlation exists between imbalance of body weight on one's feet and spinal misalignments or anomalies remains to be established. If this scale is helpful in diagnostic terms, it is certainly preferable to repeated x-rays in the author's opinion.



5. Final scale model - about 12½ x 13½ inches

In summary, the author feels that both projects were valuable as learning experiences. Certainly there are still many fruitful possible design problems for future projects in both areas -- electrical activity and weight distribution. The realism of biomechanical and bioengineering projects adds to the appeal of already challenging problems in design.

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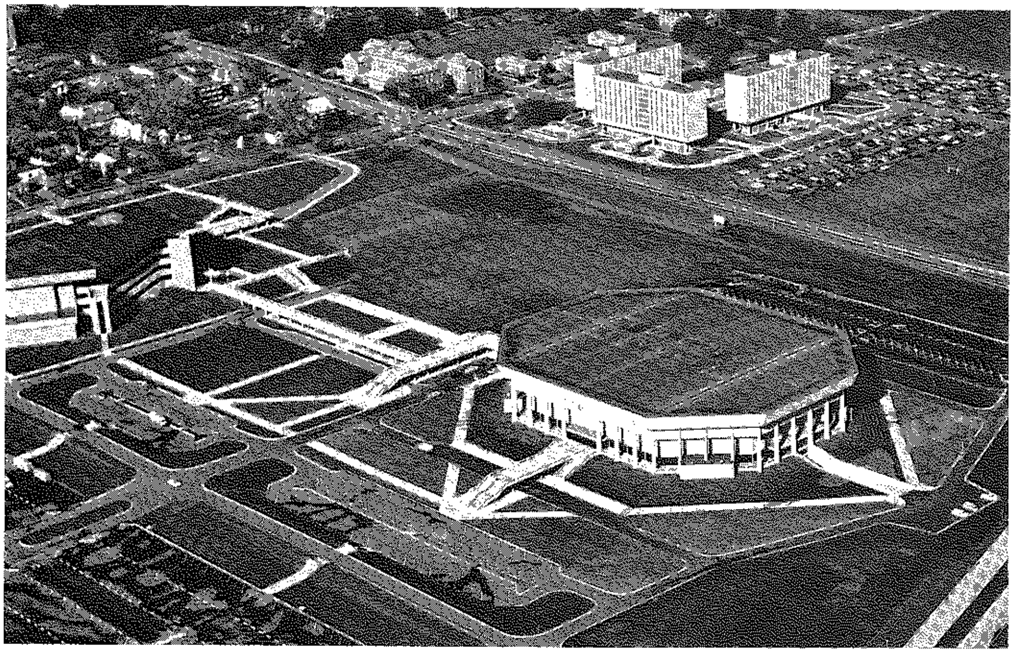


Conference Facilities - The Hilton Coliseum, lower right, will house exhibits, meetings, and recreation activities for the ASEE '73 Conference. Stephens Auditorium, left, will be used for entertainment and large group presentations. Conference headquarters will be located across the street in the modern three tower dormitory complex.

Q. name a better engineering graphics text than Earle.

A. EARLE'S SECOND EDITION.

ENGINEERING DESIGN GRAPHICS, SECOND EDITION, by James H. Earle, has just been published! It's an updated version of the standard freshman engineering graphics text that was published in 1969 and has been adopted at over 150 colleges and universities.

Like the first edition, this new one introduces students to engineering design through the application of descriptive geometry and graphical principles. This highly-readable book guides the student through the design process from problem identification to the design and analysis of his solution, including team dynamics, gathering data, human engineering, patents, technical reports, oral presentation, and final implementation.

The second edition places greater emphasis on traditional areas like working drawings, data analysis, and dimensioning. Among the other areas that have been strengthened are problems, drawings, and discussions of written reports and supervising student design teams.

ELEVEN COMPANION PROBLEMS BOOKS

James H. Earle and seven other members of the engineering graphics department at Texas A&M University have written eleven companion problems books. Five are in the series called DESIGN AND DESCRIPTIVE GEOMETRY PROBLEMS—they introduce the student to the engineering design process through a series of problems that are solved with descriptive geometry.

ENGINEERING GRAPHICS AND DESIGN PROBLEMS is a four-volume workbook series that introduces engineering, communication, and design, including instruments, geometric construction, design problems, and engineering analysis.

ENGINEERING DESIGN GRAPHICS PROBLEMS C & D synthesize, respectively, the third and fourth volumes of both problems series. They are intended for a one-semester program in engineering graphics.

If you would like examination copies of any of these books, contact Mary Clare McEwing at Addison-Wesley.

Addison-Wesley
PUBLISHING COMPANY, INC.
Reading, Massachusetts 01867

THE SIGN OF
EXCELLENCE

HOMOLOGY vs MONGE METHOD

A. Rotenberg
University of Melbourne

I write to comment on Uzi Zamonski's article "Intersection Between Curved Bodies in a Single Projection Drawing" published in the Fall Issue, 1971, of the Engineering Design Graphics Journal.

Some of your readers may be tempted to dismiss the useful method discussed by Zamonski simply because they are unfamiliar with homological transformations. It may be worthwhile to point out that the Monge method of orthographic projection on two mutually perpendicular planes establishes a homological correspondence between the two representations thus obtained. Hence, Descriptive Geometry may be regarded as a study of homological transformations of a particular type, although the term "homology" may never be mentioned in engineering textbooks or lecture rooms.

Although Zamonski refers to "rules" of homology, his constructions are equally valid when described in terms of conventional Descriptive Geometry. The important feature of Zamonski's solution is that it uses circles and straight lines only. I would like to indicate two alternative constructions which also use circles and straight lines only, and to describe these constructions in conventional terms. Zamonski's example is used to illustrate the two constructions.

Let o_1t_1 and a_1b_1 (Figs. 1 and 2) be isomatric representations of axes of rotation of two cylinders with diameters d_1 and d_2 respectively. The problem is to construct an isometric representation of the line of intersection of the two cylindrical surfaces. To make the problem unambiguous, a "secondary" projection of the axis AB (i. e. the projection a'_1 b'_1 of AB on the plane XOY) is given.

The problem may be solved by either:

(a) construction of views along the axes of rotation of each of the cylinders, or

(b) construction of a view in which two arbitrarily selected bases of the cylinders appear as circles.

The two methods are illustrated in Figs. 1 and 2 respectively.

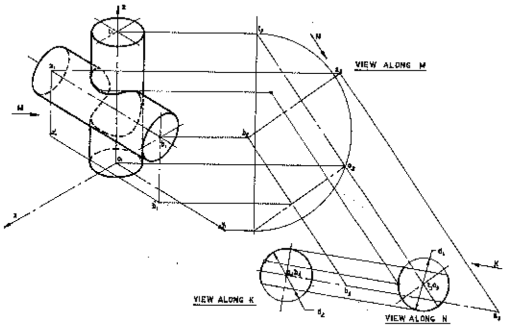


FIGURE 1

In Fig. 1, the two arcs (shown in heavy lines) in Views along N and along K may be regarded as projections of the required line of intersection. It only remains to return points of this line to the original isometric view. Construction of one point is shown in Fig. 1.

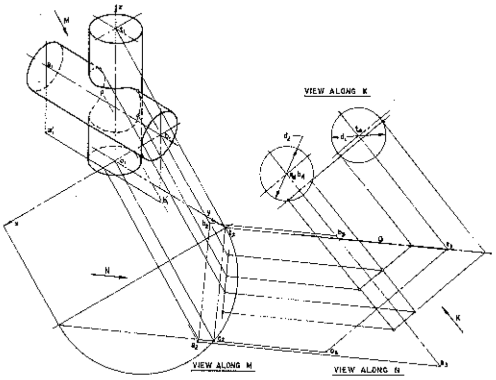


FIGURE 2

In Fig. 2, the plane Q ("View along N") intersects the two cylinders along similar and similarly positioned ellipses which, in the "View along K", appear as circles. The method of sectioning planes may now be applied to construct any number of points of the required line of intersection. Construction of four arbitrary points is shown in Fig. 2.

The constructions described here, as well as Zamonski's construction, may be quite useful when applied to solution of some problems on intersection of surfaces. There is, however, little justification for recommending any of these constructions to solution of problems in axonometric projections, for usually

(i) axonometric representations need not be executed with a high accuracy, and

(ii) since, for each surface represented, an elliptical base has to be drawn, the gain in working time is disputable.

* * *

JOURNAL Assistant Editor Appointed

Garland K. Hilliard, Jr., North Carolina State University, has accepted the appointment to the JOURNAL editorial staff to serve as Assistant Editor. He will be responsible for and coordinate the publication of all items that are concerned with the Division activities.

Professor Hilliard comes to the JOURNAL with a broad printing background. He helped his father establish and maintain a small printing business. In addition, he has had a variety of experience in the printing industry, including letterpress, lithographic layout, design composition, platemaking, and bindery operations.

He earned a B. S. and M. S. at North Carolina State University, the latter in 1969. At present, he is responsible for all graphics courses for engineering students. In this association, he developed and implemented Individualized Self-Paced Instruction for the basic graphics courses. In addition, he is the Senior advisor for freshman engineering students.

His other interests, besides this Division, include the ASEE Educational Research and Methods Division.

Since Professor Hilliard is assuming total responsibility for coordinating and reporting on Division activities, all communications relating to Division activities should be sent directly to him to avoid any delay in publication. His address and phone number will be found on the inside front cover.

Professor Hilliard has already demonstrated an organization capability in his approach to this responsibility and his contribution to the JOURNAL will be a definite asset.

* * *

News Flash -- New Division Officers

Ken Botkin, Chairman of the Elections Committee, announced the duly elected Division Officers as a result of the Annual Election. They are as follows:

Vice-Chairman (1 year term):	Claude Z. Westfall, University of Maine
Secretary (1 year term):	Ronald C. Pare' California St. Polytechnic U.
Director (5 year term):	Ralph M. Coleman University of Texas, El Paso
Journal Editor (3 year term):	James H. Earle, Texas A & M University

These officers have earned the congratulations of the Division membership. More importantly, they deserve the warm support and encouragement in discharging their duties, in the traditions of the Division.

MOBIL COMPUTER GRAPHICS LABORATORY

(Continued from the last issue)

Gerald R. McClain
Oklahoma State University

Photo showing the insides of the mobil computer graphics laboratory.
The purpose behind this laboratory is to allow the user, with a minimum of computer applications knowledge, to have the ability to communicate with the computer in a language familiar to him as a technician.

The IBM 1130 is the brain behind the "General Drafting Graphics System." The GDGS is a problem-oriented programming system that allows technicians without prior computer experience to solve various engineering related graphics problems using the basic coordinate generating and plot generating feature of the system.

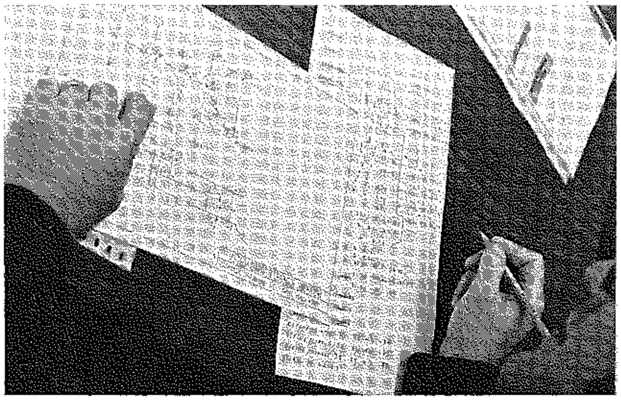
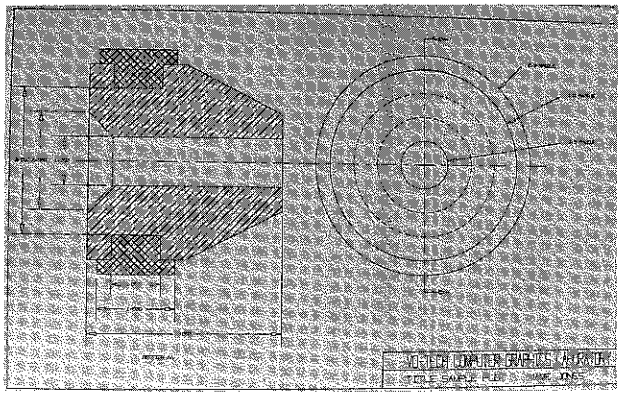


Photo showing the first step in making a computer drawing. That is sketching the part on grid paper and writing the commands in a logical construction order. Careful attention is required to transfer rough drawings into punch cards. A drafting background is extremely helpful at this point.



Final computer drawing showing versatility of the computer plotter. Notice the section lines, showing the different types of material.

(Note: The editor is solely responsible for the inadvertent omission of the illustrations which were to be included in the text of Professor McClain's article in the last issue (Winter, 1973). The editor owes an apology to not only Professor McClain but to all of his readers for this most serious publication error. A. R.)

COMPUTER-AIDED PIPE SKETCHING

John A. Roberts
E. I. duPont de Nemours & Co.

A DuPont-developed computerized pipe-sketching program delivers isometric sketches of pipe runs, lists of materials, cards for use in fabrication, purchase order information, and a history file on the job, at savings of approximately $30 per sketch. Sketches, based on coordinate system related to steelwork of plant, are delivered within minutes after input of instructions.

A DuPont engineer's frustration with the time and tedium involved in translating basic engineering design into detailed descriptions of plant pipe systems has led to a computerized pipe-sketching program that now saves thousands of man-hours in engineering detailing time and is now being made available to industry generally by the Organic Chemicals Department's Division of Education and Applied Technology.

The program, called CAPS for "computer-aided pipe sketching," enables a pipe take-off technician working from a scale model of a new plant to describe a pipe run to a computer and receive, within minutes, a detailed isometric sketch of the run, a complete list of all materials needed, punched cards for use in the shop to help machine operators in the fabrication of the pipe system, purchase order information and a history file.

CAPS had its start at DuPont's Sabine River site in Texas, where Eldon Vass, field project manager for Sabine construction projects, gathered a small group of specialists to find a way to speed up the pipe detailing operation.

From all outward appearances, the team Vass gathered did not seem the most likely task force imaginable. Typical of its membership was Jim Wilson, an expert in the pipe field who had had very limited experience with computers at the time. Soon, however, Donald Brogan, a trained computer programmer from DuPont's Engineering Department at the Louviers Building in Newark, Del., was added to the force.

The team's major goal initially was to speed such tasks as drawing up fabrication instructions for pipe shops and bill of material for ordering pipe, a job which then required many hours of tedious work thumbing through books of standards. Vass's idea was that the mass of information in both the DuPont and industry standards be catalogued in a data bank where it would be easily and instantaneously available.

Circumstances, however, led the team far beyond this initial goal. During the development period, a fast computer-driven plotting instrument became available, making possible an added goal of isometric sketches of each pipe system. In addition, new carbon steel pipe capable of being flanged and cold worked to form 90 degree bends with a nominal centerline radius equal to 1 1/2 diameters was developed by DuPont scientists working with the steel industry. (1)

Concurrently, with DuPont technical assistance, new pipe bending and flanging equipment was also developed. The new steel and cold-working machinery opened up the potential for use of computer cards to assist in bending and flanging operations.

The CAPS system begins with Eldon Vass's original goal - a data bank storing all; (1) company piping standards, (2) industry standards, and (3) fabrication shop data.

Company standards specify allowable components to be used in piping design, each with a specification number, a key word and any applicable exceptions. Certain key words are defined in all specifications. For example, "turn" involves a change in direction in a line. The program is designed to select the least costly alternative.

The industry standards bank is a file of the types of pipe and piping components available, including the dimensions and configurations of each item. Also listed are manufacturers' and industry standards for each item. This file of industry standards is used by the computer for two purposes: to provide a list of materials by manufacturers and specification number and to determine the dimensions of each component in a pipe system and the type of joints required for connecting these components.

The shop data provide an up-to-date listing of the equipment available at the fabrication shop for each site, along with the operating parameters and machine capabilities of this equipment. These data insure selection by the computer of materials and fabrication techniques suitable for each construction site, based on the least costly alternative.

This basic data bank forms a one-time input to the CAPS system that requires only periodic up-dating as new materials, equipment and fabrication components become available. For a specific design project, however, four additional inputs are needed to complete the system; (1) the specific project standards, (2) location of structural steel in the plant, (3) location of equipment nozzles, and (4) valve specifications for the particular project.

The project standards are the least complex of these four one-time inputs. Essentially, they consist of exceptions to usual company standards. The design engineer, for example, may specify a particular brand of valve or gauge where company standards normally would permit selection of any one of several similar items.

The location of the structural steel forms the framework of the computer's knowledge of the plant's geometry. The position of the steel members is referenced on an X-Y-Z coordinate system for the computer input, with one point in the structure selected as the intersection of the X-Y-Z axis.

The steel location establishes a reference system for describing the location of equipment such as vessels and pumps. These individual equipment items are positioned within the X-Y-Z coordinate subsystem referenced to individual members of the larger steel system. Nozzles on the equipment are referenced to the equipment itself by direction and distance.

The key that unlocks the computer's memory - putting it to work - is the final or "line" input, the description of the pipeline to be sketched. This description, using a unique computer language based on the jargon of pipefitters, tells the computer the pipeline's number, size and specification number; where it originates; the route it will follow; the interruptions for turns, valves, gauges, branches, and the like it will encounter en route; and where it will terminate.

Computer output being checked.

The "line" input is broken down into a manageable series of segments for the computer. For example, a simple pipeline with one branch, two directional changes, two fixed end points, one continuation end point, and three in-line items might be described in 10 steps:

1. A START, COMPF REF (EP-101, NOZ-D), SIZE = 4".
(This says, Point A, start with a companion flange which is referenced to equipment piece 101, nozzle D. The size of the line is 4 inches.)

2. B EAST, 6'-0", RUNPT
(From point A, point B is six feet east, where there is a run point.)

3. C EAST, 8'6", JOINT
(The next point is C, which is eight feet, six inches east of point B, where there is a joint. The kind of joint is determined by the computer by looking it up in the data bank.)

4. D EAST, CALC, TURN
(The line continues east to point D. This has to be a certain distance, which is governed by the location of a nozzle whose location is already fixed in the computer memory. Therefore, the input statement says "calculate the distance," and at point D, the line will turn. Whether the turn will be an ell or a bend is chosen by the computer using its data bank information.)

5. E DOWN, 2'0", RED (SIZE=4x2).
(The line turns down, goes two feet to a re-

ducer, whose size is 4 x 2. This automatically determines that the next segment of the line will be 2 inches in size.)

6. F DOWN, CALC, COMPF, REF (EP-9775, NOZ-B), STOP.
(The line continues down to point F, a distance which the computer must calculate, since point F is a companion flange which is referenced to equipment piece 9775, nozzle B, and the line stops there. Since point F is fixed, both the segment from C to D and the segment from E to F can be dimensioned.)

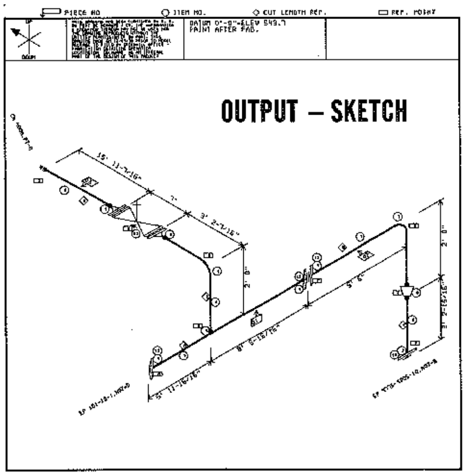
7. B RESTART, BRANCHPT, SIZE=2"
(The line restarts back at point B, because B is also a branch point. The line size is two inches.)

8. G UP, 2'-0", TURN.
(The line goes up two feet to a turn at point G. The type of turn, whether a bend or ell, is determined by the computer.)

9. H NORTH, 3'-6", VALVE (G21F, STEM = U, FLOW-F).
(The line then turns north and goes three feet six inches to the center line of a valve, which is point H. The valve is specification G21F. Its stem is up and flow is forward. By reference to the data bank, the computer determines that the valve is seven inches from face to face and adjusts the pipe segment from three feet, six inches to three feet, two and a half inches. It also remembers to do the same for the next segment.)

10. I NORTH, 16'-3", TE, NOTE (CN400A, PT-A), STOP.
(The line goes 16 feet, three inches from the centerline of the valve to point I, where there will be a joint and the following note: "This line will continue as Line 400A, point A, on another sketch." This line stops at point I.)

With this final "line" input, the computer is ready to produce an isometric sketch illustrating the pipeline. Before activating the plotter-printer, however, the computer rotates the orientation of each sketch into four quadrants to select the best perspective as the one for printing. The sketch is then printed (Fig. 1), with all dimensions provided and allowances for gaskets and weld gaps automatically made.



The Computer System where fabrication for the pipe shops can be obtained in minutes.

In addition, when requested, the computer will provide data on pipe material requirements, data on fabrication techniques including specific cut lengths and bends. Punched cards provide information and work station requirements, purchase order information and a history file. The rapid availability of this information makes it possible to coordinate closely the many activities that follow sketching - inventory checking, purchasing, ordering fabrication of lines, and scheduling work and labor cost programs, as well as providing statistics for future use.

The CAPS system has been widely used in production at DuPont construction projects over the past two years and now is saving thousands of man-hours of work. The savings are most dramatically illustrated by the system's sketching capabilities alone. In its construction program, the DuPont Company requires more than 30,000 pipe sketches annually. The CAPS system is producing some 95 per cent of these sketches. Even considering the costs involved with the system, computer aided pipe sketching results in annual cost savings for sketches of approximately $1 million.

REFERENCE

(1) N. E. Whitcomb, Chem. Eng. 71, No. 1, 71-74 (Jan. 6, 1964)

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Division Program - 1973 Annual Meeting

MONDAY

7:30 - 9:45 a.m.
EXECUTIVE COMMITTEE - BREAKFAST MEETING(Closed)
William B. Rogers, V.P.I., Chairman
Engineering Design Graphics Division

3:45 - 5:30 p.m.
METRIC STUDIES - Historical Background, trends toward adoption, ramifications and consequences of the metric system
William H. Lichty, General Motors Institute

8:00 p.m.
ENGINEERING GRAPHICS and DESIGN - A "rap" session between members of the ASEE Design Committee, the Mechanical Engineering Design Committee and others on the general subject of engineering design
Kenneth E. Botkin, Purdue University

TUESDAY

12:00 - 1:30 p.m.
DIVISION LUNCHEON and BUSINESS MEETING (Open)
William B. Rogers, V.P.I., Chairman
Engineering Design Graphics Division

1:45 - 3:30 p.m.
GEOMETRIC TOLERANCING - Taped color TV presentations describing the fundamental principles and techniques involved. Various practical applications illustrated. Commentary by those presiding.
Eckhardt E. Sautter, General Motors Institute
Robert J. Christenson, General Motors Inst.

6:00 p.m.
ANNUAL AWARDS BANQUET
Featured Speaker: Mr. Frank Miller, Pulitzer Prize Winning Editorial Cartoonist for the Des Moines Register
Presiding: William B. Rogers, V.P.I., Chairman, Engineering Design Graphics Division

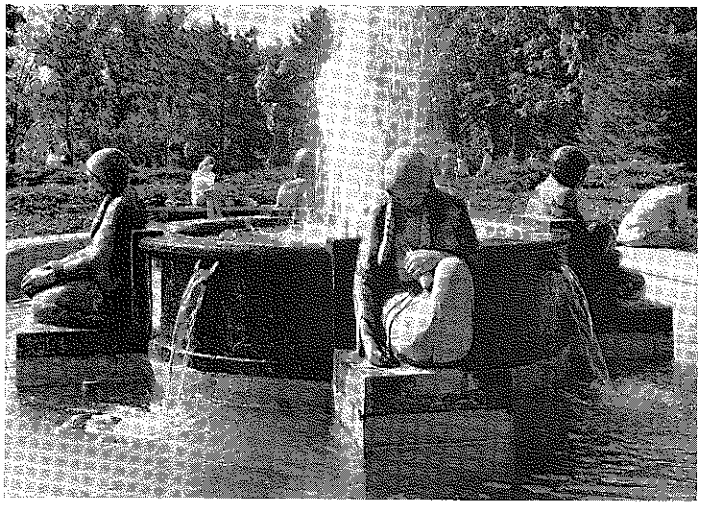
WEDNESDAY

8:00 - 9:00 a.m.
LISTENING TO THE VOICES OF SMALLER INDUSTRIES ON ENGINEERING EDUCATION - A panel discussion
Presiding: Joe V. Crawford, Iowa State Univ.
Panelists: Richard Wilcox, Senior Project Engineer, Delevan Manufacturing Company; John Scholten, Vice President, General Filter Company; Donald Porter, President, Berkley Company; Leo Classen, Chief of Air Quality Division, Iowa State Department of Public Health; Representative from Winnebago Industries (to be announced)

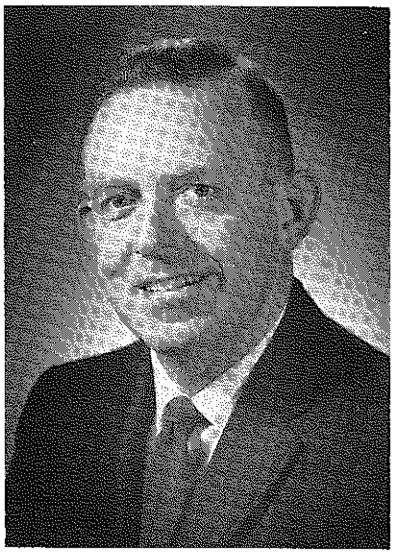
9:15 - 11:45 a.m.
"THE MARRIAGE OF MEDIA" - A 3-stage tour of facilities available to the Engineering graphics Department at Iowa State Univer.
Paul S. DeJong, Iowa State University
Arvid R. Eide, Iowa State University

THURSDAY

9:00 - 10:45 a.m.
NEW USERS SESSION - COMPUTER GRAPHICS
Presiding: Edward V. Mochel, University of Virginia
Where Do We Get Started in Computer Graphics?
Curtis Hertel, University of Missouri-Rolla
How Do We Catch Up in Computer Graphics?
Clark Pidgeon, Queens University, Kingston Ontario



Fountain of Four Seasons - Conference participants will be able to stroll among the many beautiful gardens, trees and sculptures on the Iowa State University campus.



Backward Glimpses and Forward Projections

William B. Rogers
Chairman, 1972-73

Like Francois Villon, the 15th Century vagabond poet of France, with emotions ranging from ambition, to rage, to despair, most of us have thought, "If I were King!" "If I were King!" I would accomplish wonderful things. My kingdom would be different. I would show them. I would get things done, "If I were King!"

When one is granted the privilege of reigning for a brief period over even the most limited kingdom, one soon learns that the view from the throne is quite different from what might have been imagined. Even in the most absolute monarchy, a royal decree is executed with a certain amount of foot dragging, and in a society where all men claim the "divine right", kings are easier to find than serfs. Significant accomplishments, however, are wrought slowly by repeated applications of the peasant's spade and rarely overnight by a single wave of the royal scepter.

This "king" has made no effort to effect dramatic change but rather has been attempting to implement programs already recommended and to prepare the ground for several long range programs which should bear fruit over the next four years.

The primary thrust of this administration has been toward implementing the recommendations of the Division's Self-Study Committee. Implementing these recommendations will require a number of changes in the Division's by-laws, and revised by-laws have been drafted by the Implementation Committee, carefully studied, and further revised by the Policy Committee. The new by-laws should be ready for presentation to the membership at the Annual Conference in June, 1973, at Ames, Iowa.

The Division publication, Engineering Design Graphics Journal, has been the subject of considerable criticism and concern over the past several years. A committee recently completed a comprehensive study of the Journal, and a report was published. Some of the recommendations in this report have been implemented, others will be, while others were not considered feasible at this time. This administration has two objectives with respect to the Journal: 1) To improve the quality and professional content of the published articles to the point where our readers look forward to receiving and reading the Journal; 2) To distribute the Journal free to all members of the Division. It is believed that with these two objectives accomplished, advertising revenue will provide adequate financial support.

The majority of members attend neither the Annual Conference of the Society nor the Mid-Year Conference of the Division. Many of these members do attend the conferences held by their sections. This year zone and section representatives were appointed on an interim basis with the goal of arranging at least one Engineering Design Graphics Division session at every Sectional Conference. The new by-laws provide for a director of zones activities, a new position in the Executive Committee. A few sections presently have a Division organization within the section. No overlapping of responsibility is contemplated in these cases, and it is hoped that within a few years all sections will have a Division organization with officers elected by the sectional membership. Much can be accomplished by the Division at the sectional level.

One of our past chairmen upon hearing of my election to vice-chairman two years ago remarked, "You will enjoy your year as chairman; you will be working with a group of the finest people in the world." As the tenure of this administration comes to a close, the full impact of this comment is more completely comprehended. Whatever the "king" may have accomplished has been through the spade work of some of the finest people in the world. Thank you all.

You and the JOURNAL News

Your Journal has set a goal to become more actively involved in reporting the news among its subscribers and members of the Engineering Design Graphics Division. To partially fulfill this goal, I have been appointed Assistant Editor with the specific responsibility for serving as news editor. To fully realize its goal, however, the Journal needs you.

Each of us, as either members of the Division or as subscribers to its Journal, has a professional responsibility to contribute his share in the dissemination process. The Journal, the mouthpiece of those sharing common interest, stands at the forefront in reflecting the ideas, ideals and activities of its readers. Through the printed word, it unifies individual effort toward common goals. If the Journal is to blazon forward as spokesman, its success will be the result of the full support and cooperation of each and every member.

True, our national, regional, mid-year and annual conferences offer the opportunity for both formal and informal exchange of ideas, experiences, new developments, etc. Needless to say, however, most members are unable to attend either frequently or infrequently, any or all conferences sponsored by our Division. The Journal, on the other hand, provides all its readers a single-source reference and permanent record of past, current, and future Division activities.

Although many news items originate from the various committees of our Division, you, the reader, may have significant news items that would be of broad national interest to other readers. For example, you or someone you know, may have received an award, published a book, presented a paper, organized a workshop, developed a teaching method or technique, etc. that you wish to share with other readers. Maybe you have heard a recent joke or laughed over a cartoon that would befit Journal publication. In contrast, however, you may wish the Journal to announce the death of one who was devoted to our mutual interest. There are surely other local, significant items you feel deserve national attention in the Engineering Design Graphics Journal.

The Journal is oiling its bearings and synchronizing its gears. It is Press Time! The Assistant Editor is counting on you to provide the energizing news that will transport you and our great organization to new horizons.

Help me report the news more effectively by referring your news items to:

Garland K. Hilliard, Assistant Editor
Engineering Design Graphics Journal
239 Riddick Hall
North Carolina State University
Raleigh, North Carolina 27607

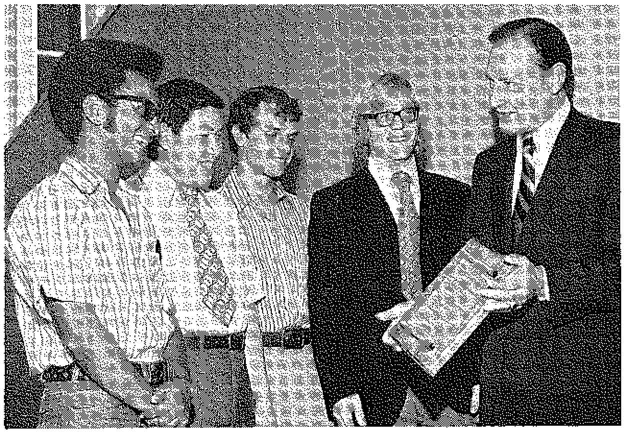
To insure coverage in the most recent issue of the Journal, please submit your news items prior to the following deadlines:

Spring Issue - February 15
Fall Issue - August 15
Winter Issue - December 15

With your help, you, the Journal, and the Division can reach new heights of excellence!

Garland K. Hilliard
Assistant Editor (News)

ASU Students Honored

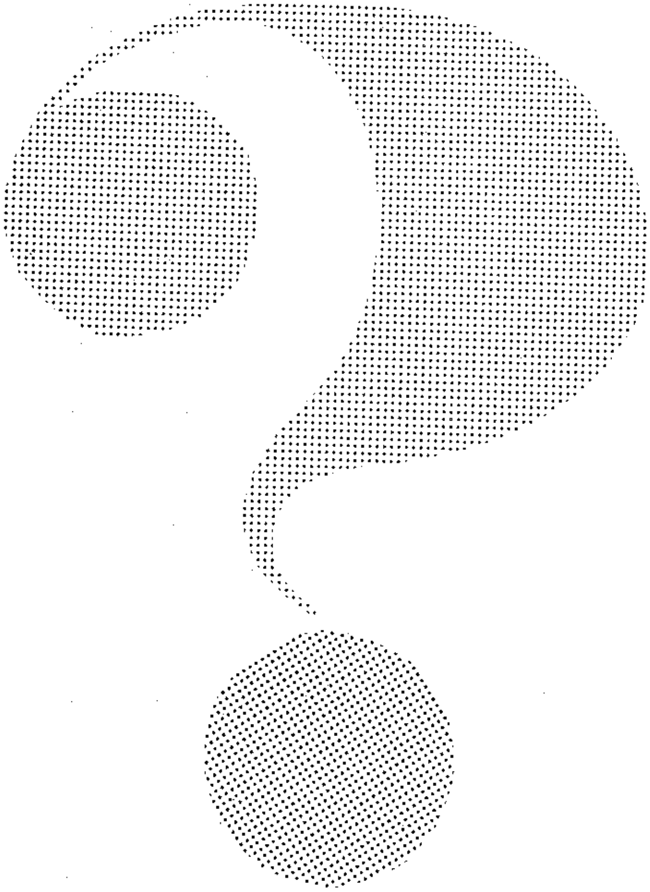


Shown above are four Arizona State University students receiving the very beautiful first place award plaque for their design submitted in the ASEE Creative Design Display competition in Lubbock, Texas last June. From left to right the recipients are Yilma Gebremariam, David Hom, Val Dietrich and John Durand being presented the award by ASU President, Dr. John Schwada.

The design team of six (two of whom are not pictured), as freshmen, designed and produced a writing-aid device for quadriplegics. The team named themselves appropriately, "The Hope Company." John Durand, who originally thought of the writing device idea, will be putting his engineering knowledge to good use in the future. He is an engineering sciences major with a pre-medical option.

journal AUXILIARY

bits and pieces



This space is empty this issue, but with your help will appear regularly with future issues. Let's see if we can't fill the emptiness and give it life.

If you have a short announcement: a promotion, a paper, a new book, a few words of wisdom, a bit of humor, have moved to a new position at a new address, have a question that one of our readers might answer, etc., and it does not warrant printing elsewhere in the Journal, jot it down. Send it to the Assistant Editor, and we will try to publish it in our next issue.

Revised By-Laws

The members of the Policy Committee, the Self-Study Committee, and the Executive Committee who were at the Mid-year Conference in Denver met in a special meeting to discuss proposed revisions to our Division's By-Laws. These changes are necessary to make possible the recommendations of the Self-Study Committee, to update the language to conform to changes within the ASEE, and to provide for some possible exigencies that were not provided for in the present By-Laws.

After a rather long meeting, the combined groups agreed on all proposed changes except those affecting the Journal. It was agreed that suggestions as to these parts of the By-Laws would be sent to a special ad-hoc committee consisting of Borah Kreimer, Bill Rogers, and Bob Hammond. This group will get together in April and will arrive at a compromise regarding this specific area.

The complete proposed By-Laws will be available to all members at the Annual Conference in Ames, Iowa. To become official, they must be accepted by a vote of two-thirds of the members of the Division who are present. (This gives everybody an extra incentive for attending.) To attempt to make it easier for the membership to carefully go over the proposed By-Laws, copies of them, less Article VIII--PUBLICATIONS, will soon be mailed. Thus, those attending can concentrate on this new Article when they arrive at the Annual Conference. So, I hope to see you all at Ames.

Bob Hammond, Chairman
Policy Committee

Tax Deduction for Education

If you are finding it difficult to justify the expense incurred while attending our 1973 Annual Meeting, maybe this will help.

Treasury regulation 1.162-5 permits an income tax deduction for educational expenses (registration fees and cost of travel, meals and lodging) undertaken to: (1) maintain or improve skills required in one's employment or other trade or business, or (2) meet express requirements of an employer or a law imposed as a condition to retention of employment, job status or rate of compensation.

Computer Graphics Committee Sets New Plans

Mr. Byard Houck, Chairman of the Computer Graphics (CG) Committee, reports that the Committee has been working diligently to try to identify the major problems and goals affecting this new design technique. The CG Committee has suggested four main objectives for the Division.

First, it is deemed dssirable to improve the competitive position of Computer Graphic projects in the Creative Design Display. It is intended that this be done by: (1) increasing computer graphic participation in Creative Design Competition and (2) improving the CG projects submitted so that they are of a caliber to merit serious consideration for top honors in design competition.

Secondly, it is felt that the most important goal of the Committee is to increase cooperation among persons doing computer graphics work. It is intended that this be done by: (1) fostering an increase in personal correspondence among these people, (2) encouraging the exchange and sharing of computer programs which are useful in obtaining graphic output, and (3) encouraging the sharing of instructional materials in the CG field.

Third, a "New Users" session is planned for Iowa State. It is intended to: (1) provide a followup for the computer graphic summer school at Lubbock, (2) provide a forum whereby New Users can discuss their joys and problems, and (3) provide an atmosphere for sharing CG implementation experienced between New Users.

Finally, the CG Committee feels that is is desirable to encourage an increased number of computer graphic articles in the <u>Engineering Design Graphics Journal</u>.

Byard Houck, Chairman
Computer Graphics Committee

* * *

Computer Graphics Short Course

A two week graduate course in <u>Computer Graphics</u> will be offered July 9-21, 1973 at North Carolina State University. This course is for instructors in the fields of Mechanical, Civil, and Industrial Engineering and Technology. Terminal managers are also invited. It will assume a basic working knowledge of the FORTRAN computer programming language, but nothing more.

North Carolina State University has developed a computer graphics language called TRIDM which uses the FORTRAN language to define objects, data curves, and flow charts in space. With this language, objects can be moved around in space, rotated or manipulated, scaled, and subsequently drawn as orthographic and pictorial views. TRIDM is a language which uses "natural" commands to get work done by the computer. Such commands as OBJS, ROTA, SCAL, ORTH1, ORTH2, ORTH3, PERS1, PERS2, and PERS3, etc. are used to request orthographic drawings, perspective drawings, etc. of an object.

Various computer subroutine packages will be constructed during the course to share information, manipulate data, and display information in graphic form. Instructors will have experience in submitting and manipulating programs of interest in engineering. Basic mathematical manipulation theory will be demonstrated with regard to its utility in dealing with "flat" or "warped" surfaces. The course also intends to provide a survey of the capabilities of computers in the graphics field for those individuals who wish to expand on their knowledge and use of the computer as an engineering tool.

Information regarding fees and registration for this course will be distributed through June 15 by contacting Professor Robert H. Hammond, 239 Riddick Hall, North Carolina State University, Raleigh, North Carolina.

Denver A Success

Ninety-four people attended the mid-year meeting of our division in Denver, Colorado. According to reports, the accomodations, the hospitality, and the organization were super. Frank Oppenheimer and his helpers should all wear bright colored feathers in their respective chapeaux as a reward for a great job, well done. The buses, beer and broncos were in perfect harmony with western tradition.

The technical meetings were outstanding--the sessions on earthquakes were very nearly world shaking. "Summing up," says Gordon Sanders, Chairman, Program Committee, "I have attended several fine mid-year meetings and judged this one to be tops."

Editorial

Whither the JOURNAL?

Al Romeo, Editor

In the long history of the ASEE Division of Engineering Drawing (now the Engineering Design Graphics Division), the Division has been ably served by members who voluntarily gave of their time and energies to provide a continuing and progressive organization. The Division has been fortunate in the past that dedicated people were willing to step forward to assume these responsibilities.

Over this long period members of the Division have, on occasion, asked themselves "Where should the Division be going?" At the present time, the Division has just completed a self-study to answer this question. The Chairman has charged an Implementation Committee (under Borah Kreimer) with the responsibility for an orderly implementation of the recommendations of the Self-Study Committee.

One of these recommendations included a self-study of the Journal. A Self-Study Committee for those recommendations related to the Journal is being chaired by Steve Slaby.

It is most appropriate that the self-study of the Journal occur simultaneously with the implementation actions in the Division. It is most important that the Journal meet the needs of the Division and its members. Since the objectives of the Division have changed, there is no question that the objectives of the Division's publication must change to lend support to the efforts and aims of the Division and its members. As Professor Slaby put it, "the publications of our Division reflect the quality and goals of our Division."

There have been numerous recommendations as to how the Journal can best support the needs and goals of the membership. Among them are the following:

1. The Journal to become a scholarly journal devoted to formal papers only.
2. The activities of the Division and its members to be published in a newsletter of more frequent publication dates.
3. The Division's publication office and the Journal's administrative operations be restructured to execute the above objectives.

These are worthwhile objectives. Our Division contains talented and thoughtful members who would support the objectives of the Self-Study Committee. These members would ultimately conclude that the objectives are desirable, by providing the mechanism with which they can be executed in an effective manner.

The membership should support the goals of the Division's Implementation Committee, as well as the Journal's Self-Study Committee by providing guidance as individuals, making their views known and, finally, supporting the recommendations as they are adopted by the Division.

What do you think the objectives and goals of the JOURNAL should be?

Letters to the Editor

To the Editor:

Along with my congratulations to L. C. Baird and Frank Marvin on their article in the Fall, 1972 issue, "Mathematics and Graphics --- Getting the Point Across," I must make two serious comments. The first has to do with the title of the article. The second has to do with their statement, "A precise solution to the problem can only be obtained analytically."

There is no doubt that teaching any topic from two viewpoints or by two different methods fortifies a student in his knowledge of that topic. But to call one system "mathematics" and the other "graphics" is to separate the inseparable. Since when is graphics not a branch of mathematics? Is plane geometry not mathematics? Solid geometry? Projective geometry? And isn't descriptive geometry simply a special case in projective geometry? Why, then, do we always seem to fail to identify graphics with mathematics? Vector analysis is certainly called mathematics, yet it's not less graphical than graphics.

If you must make a distinction try something like graphical mathematics and symbolic mathematics. At any rate, we are wrong to rule ourselves out of the vast field of mathematics and I think it is demeaning to try to show that we can get results with "graphics" that are pretty close to the results we can get with "mathematics."

And this brings up the second matter. I object vehemently to the statement quoted above, that "A precise solution to the problem can only be obtained analytically;..." and a few pages later, "Accuracy is limited only by the number of decimal places one wishes to carry."

The precision of an analytical solution depends upon the "precision" with which the data were obtained. If the x-y-z coordinates of the endpoints or any other points of the lines were taken from graph paper or measured from some reference point or line, themselves graphical and therefore imprecise, there is no way to get a precise solution by any method. Carrying a number to a long string of decimal places doesn't make it a bit more precise than the original "precision" of the data.

None of this is intended to diminish the Baird-Marvin story in the JOURNAL. It was a fine piece of reporting and the students involved surely benefitted by the experience of seeing a problem done in different ways and in different terms. Having taught recently in both fields, descriptive geometry and calculus, I can state that some of my best friends are mathematicians. Some are graphical mathematicians; some are analytical mathematicians. The pity is that rarely do we find them in one person.

Gleefully yours,

Irwin Wladaver
Associate Professor Emeritus
of Mechanical Engineering
New York University

AUTHORS' RESPONSE

To the Editors:

After reading Professor Wladaver's comments, we can only agree and ask that our readers use his letter as an addendum to our article. However, we do feel a few pertinent remarks might help to clear up any misunderstandings. We didn't call one system mathematics and the other graphics. These subjects and names were "invented" long ago and are a part of our heritage. One purpose of our effort was to strengthen the close relationship of these two areas of engineering education. We had no intentions of even implying that mathematics and graphics were different, detached, unrelated subjects of study. Unfortunately, at most engineering colleges, mathematics is taught by the Department of Mathematics - usually in the College of Arts and Sciences - and Engineering Graphics is taught as a service course by one of the degree granting departments within the College of Engineering. If Professor Wladaver can do something to improve this situation, we will support his efforts.

As for accuracy, we were simply trying to emphasize that the accuracy of a graphic solution is limited by the instruments used and the skill of the individual. Assuming the same input, a mathematical solution is "precise."

In support of the last thought in Professor Wladaver's letter, one of us is an analytical mathematician; the other is a graphical mathematician. We are two people, but we wrote one article - Mathematics and Graphics -- Getting the Point Across.

Mathagraphically yours,

L. C. Baird, Dept. of Mathematics
Frank F. Marvin, Div. of Engr. Fundamentals
Virginia Polytechnic Institute
and State University

To the Editor:

The title of this letter ought to be "Plus ça change, plus c'est la même chose."

I thought you might be interested in the following item that appeared on the editorial page of the issue of May, 1958. It was the final issue under my editorship. I quote myself from page 12 of that Issue:

> WHAT'S IN A NAME?
>
> There is fairly substantial agreement, we believe, that the name of our Division no longer fully reflects what we are doing in our classrooms toward the education of young engineers. Should we change the name?
>
> The members of the Executive Committee have debated the matter at great length and have reached only one conclusion: That such an important step must not be taken lightly. The decision was to submit the subject to the membership at large for the guidance of the Executive Committee.
>
> This is not just lip-service to democratic action. Your opinion is not only wanted; it is needed. Please let the Executive Committee know your feelings about whether or not the name of the Division should be changed and, if so, what the new name ought to be.
>
> We earnestly hope that everyone who has opinions will speak up while there is still a chance to say yes or no.

To add fuel to the fire, Professor Matthew McNeary wrote an article that appears on page 46 of that same Issue, "A Change in Name for the Division." I guess the French were right, this once anyway: The more change, the more similarity.

Cordially,
/s/ Irwin Wladaver
Irwin Wladaver
Associate Professor
Emeritus of
Mechanical Engineering
New York University

● ●

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Major Wins Award

At the 1973 Engineering Design Graphics Division Mid-Year Conference in Denver, Colorado, Professor Maurice W. Major won the Oppenheimer Award for his outstanding paper presentation at the conference. Professor Major is a member of the Department of Geophysics faculty at Colorado School of Mines in Golden, Colorado. His paper was titled, "Earthquakes Caused From Discharging Toxic Wastes Into Deep Wells" and presented insight concerning the apparently man-made earthquakes in the Denver area. By being selected as the best of eight presentors, Professor Major wins a $100 cash award and a handsome certificate.

The Oppenheimer Award is offered twice yearly, once at the Mid-Year Conference and once at the Annual Conference of the Engineering Design Graphics Division. Frank Oppenheimer of the Gramercy Guild Group established the award to encourage and reward excellence in presentation of papers at Division meetings.

Division Co-Sponsors Short Course

Entitled, Introduction to Occupational Safety and Health, with instructors from the National Institute for Occupational Safety and Health (NIOSH), the course was intended to familiarize the trainee with the chemical and physical agents and related hazards which the worker encounters in the occupational environment. Diseases, especially of the skin and respiratory tract, were discussed in relation to excessive exposures. Although the lectures focused on the recognition of hazards, some aspects of the measurement and control of these exposures were discussed.

The New England Chapter of the Human Factors Society in conjunction with the Engineering Design Graphics Division of ASEE and Tufts University sponsored a one-week introductory training course on Occupational Health and Safety. The course was presented at Tufts University April 2-6, 1973.

* * *

1973 Creative Design Display

It looks like a good year for the Creative Design Display at Ames this summer. Paul DeJong says the display will be held in the Hilton Coliseum outer concourse, opposite the commerical displays. The central location affords not only a spacious straight-line display, but there is also a good 360° view of the river valley.

As of January, Ron Pare reported more than 52 potential design projects for competition which suggests a large display! Bob Britton of Missouri has empanelled an impressive list of twenty-three (23) judges from industry and education to evaluate the designs.

The Journal, on behalf of its readers and members of the Engineering Design Graphics Division, expresses its deep appreciation to the following industries for their monetary contributions in helping to make the Creative Design Display a featured attraction at our Annual Conferences:

Dupont
McDonnell Douglas
Standard Oil of N.J.
Zenith Radio

The Journal apologizes if there were any other industries that contributed since the January 8, 1973 Treasurer's Report.

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