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JOURNAL OF ENGINEERING GRAPHICS

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EDITORIAL

These are important years for the Division of Engineering Graphics. We can anticipate continuing scrutiny of engineering courses by faculties and evaluating committees in their attempt to squeeze more and more into the undergraduate's program as well as to shape the curriculum to meet the needs of tomorrow's technology. The Grinter Report accelerated the trend toward analytical and mathematical approaches to problem solving at the expense of those courses teaching synthesis and design. However, there is some indication that the de-emphasis of design in engineering schools is stirring a significant number of the leaders of our industrial and engineering community to protest.

The heart of the matter for Graphics instruction in this country's engineering schools is the continuing vitality of the subject matter and its fundamental importance in the training of the creative design engineer. This vitality and advancement depends directly on the college teachers of engineering drawing, descriptive geometry, fundamentals of design, or what we broadly call Graphics Science. Such bold programs as manning space vehicles to explore the moon will only be possible with continued excellence in teaching and research in Graphics Science.

The Journal of Engineering Graphics can serve the Division in important ways. It can communicate the problems of the Division and their possible solutions. It can also reflect the importance of Graphics to engineering and science. But this is only possible if the members of the Division continue to take a lively interest in their Journal. Your newly elected editor is calling on you to help supply the news, the research articles, and advances in methods of teaching.

There are several exciting news items in this issue which indicate that Graphics Science is on the move. The National Science Foundation is underwriting a two-year study of Graphics Course Content. This is a project which should be of great importance to the future of our division. It is the realization of long planning and effort by Professor Paul Reinhard of the University of Detroit. The second item is the proposed International Conference on Space Geometry at Princeton University in 1963. This project is sponsored by Professor Slaby.

It is planned to have at least one article in each of the forthcoming issues of the Journal on some facet of Graphics as taught in high schools. At the same time that Graphics instruction is advanced on the college level, we could examine the teaching of engineering drawing in the high schools and technical institutes. We should actively encourage upgrading of instruction, coordination of high school and college programs, and participation of instructors at all levels of education in regional programs concerned with improvement and advancement of Graphics methods.

The instruction of Graphics on the college level must continue to be done by teachers who will advance the subject on a high intellectual level. This imposes a responsibility on the present teachers and researchers in Graphics to enlist and train younger teachers and to encourage them to explore exciting avenues of advanced Graphics as well as rewarding teaching adventures. This Journal carries the first of a series of Case Histories for creative teaching. It also carries two applications of descriptive geometry -- in electrical engineering and chemistry.

One benefit of the editor's uneasy seat is the review of past Journals. With this review there has been a growing appreciation of and admiration for the work and devotion of the past editors. To maintain the high standards achieved in the Journal since its inception has required great diligence and patience. In the production of this issue your new editor has suddenly had to master a new world of competence. The arts of "paste-up," "mechanicals," "stats," and "dummies are added to the requirements of articles, illustrations, and advertisements. This issue has been produced with the cooperation of my Cooper Union colleagues. I thank them.

Please send your comments, manuscripts, and suggestions for inclusion in the February issue. Deadline January 1, 1962. Happy New Year!

Sincerely,

Mary Blade

Mary Blade, Editor

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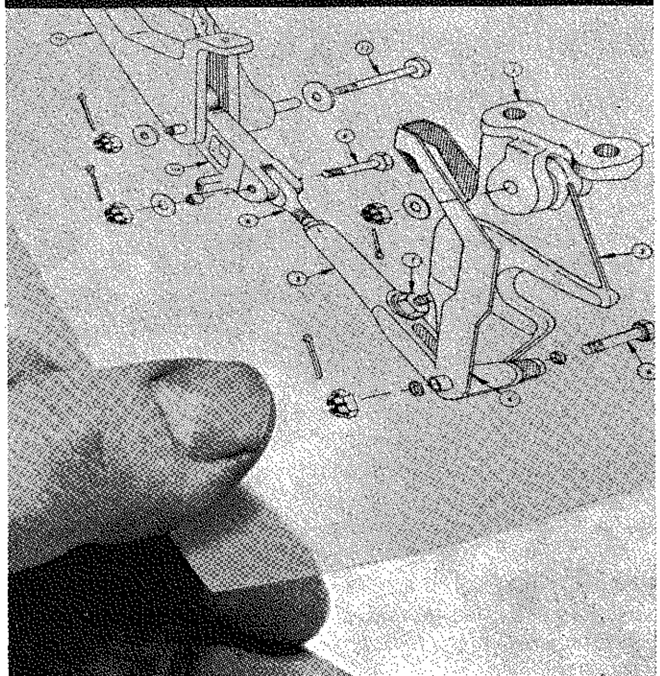

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THE CONSTRUCTION AND FOLLOW-UP OF A FINAL EXAMINATION FOR ENGINEERING GRAPHICS

By Dr. Robert Borri, Associate Professor of General Engineering, University of Illinois

The purpose of this article is to examine some of the important factors involved in constructing, administrating and interpreting the students' achievements in a final examination for a beginning college course in engineering graphics. Also covered are the applications of these basic principles in the construction of a final examination including a brief statistical analysis of the results.

In the construction of a final examination for engineering graphics, the various characteristics of a good test were considered and as many as possible were incorporated to insure a test which would be suitable, detailed, comprehensive and analytical. Some of the characteristics given special consideration were validity, reliability, objectivity, diagnostic value, ease of administration, and economy of time in grading.

Validity. Validity has to do with the degree to which the test measures what it is supposed to measure, that is, a test which contains significant items. The opinions of the curriculum committee and administrators in the department were pooled to analyze and pick test items considered fundamental and in accordance with the objectives and the content of the course. About 275 test items were assembled and from this working list, a carefully selected and refined list of items involving 185 points was agreed upon. Later, when the test time was reduced from four hours to three hours, the total number was further reduced to 125 points. Some of the original items that had been removed were used later to make alternate forms of the examination.

Since in many achievement tests validity depends, to a large degree, upon the opportunity which the student has had to master the material in the course, the number of items on each topic was made to correspond relatively, as far as possible, to the number of periods spent in studying the topic. (Fig. 2) The topics covered in the test included practically all those listed as essential for adequate training in engineering drawing as given in "A National Survey of Engineering Drawing," an early study conducted by the Drawing Division of the ASEE.

Reliability. The reliability of a test may be thought of as the consistency with which it performs and, like validity, stresses test efficiency. The coefficient of reliability of the final examination was found by the "split-half" technique. The test was divided into two parts -- the odd-numbered tasks and the even-numbered tasks -- and the degree of correspondence between the two parts was computed. The coefficient of reliability for the final examination for four classes enrolling eighty-seven students was found to be .93 for either half of the examination. By using the Spearman-Brown prophecy formula, the estimated coefficient of reliability for the entire examination was found to be .96. (Table 3) Since "1" means a perfect correlation, .96 indicates a reliability coefficient with an excellent rating. The length of this examination and the wide distribution of student performance were other factors indicating a high reliability coefficient.

Objectivity. The quality of objectivity in a test contributes indirectly to validity and reliability because it aids materially in the elimination of the subjective factors in scoring. The objective test items were formulated, insofar as possible, so that only one correct response satisfied the condition of the exercise. To measure the various types of thinking different forms of questions were included, such as: true-false, matching, recognition, definition, completion, multiple-choice, and scale computation. These questions covered the basic principles of engineering graphics while fifty-six of the 125 points were devoted to drafting problems involving spatial relationships, and gave an indication of the students' use of the technical information. Figure 1 shows the type of questions and the per cent of points allotted to each. In most cases, the test items were made brief to permit the widest sampling. It was the aim of the curriculum committee to use as much test refinement as possible to avoid ambiguous and negative statements, eliminate suggestive items, let chance determine the order of true and false statements, avoid the use of verbal clues, and keep the examination free from linguistic irrelevancies.

Administration and Scoring. Concise and simple directions were included with the test to make it easy to administer and simple to interpret. The test was neatly reproduced, and the pages were stapled together for easy distribution and gathering. The front sheet gave an outline of the qualities measured by the test both with respect to the topics and to the number of items of each topic. Directions for each part were included as was the definite statement of a time limit. A key with the correct responses, supplemented by brief directions, was furnished each instructor scoring the test. Since this was a new test at the time, no norms were available, but because of the nature of the examination, it was decided to calibrate the test on a mathematical-equivalent basis. A "point per cent" conversion table was also provided; with it an instructor could readily convert the student's total raw score to its equivalent in per cent.

Diagnostic Value. All examinations have some diagnostic value but the engineering graphics final examination was especially constructed to give maximum diagnostic information. Unlike many examinations, the items were grouped according to subject matter or topic instead of as to type of question. In this way the trend of thought was kept more intact and the exact identity and location of the pupils' strengths and weaknesses were discernible and easily plotted on a profile chart. Thus, the achievement on each part of the test by all the students, one division of the University, one class, or an individual may be easily seen, and definite suggestions for improvement made on the basis of the weaknesses revealed by the test. (Fig. 5)

Achievement. The accomplishment on the final examination by the students of each of three divisions of the University is shown graphically in Figure 4. All three curves resemble the well-known normal probability curve except for a slight skewness to the left. Some of the differences in achievement of the various divisions were probably due to the newness of the divisions at the time the data was gathered.

The highest grade made on the examination by students in three divisions of the University was an identical 97% while the fourth division with 95% indicated a small variation. There was marked difference in the lowest grade made; scores varied from 59% at Division 1 to 30% in Division 3. The widest distribution of achievement was found in Division 2 with a range of 67%; next were Division 3 with 63% and Division 1 with 50%. Division 4 showed the smallest range -- 37% -- as should be expected because of the small number of students involved. The quartile deviations varied but little in all the divisions and indicated that the scores made in the examination were concentrated to approximately the same degree about the median.

Conclusion. In constructing a good final examination in engineering graphics, the instructor should consider the following principles of measurement:

1. Select critically items from the important phases of the course which have been given instructional emphasis, so that the validity of the test is insured.

2. Obtain a wide sampling over the significant phases of the course so that the test will be long enough in terms of items and working time to secure reliable results.

3. Cover information-type items with objective-type questions that best fit the material.

4. Specify directions and conditions for giving the test so as to standardize and ease its administration.

5. Provide a key with the correct solutions to economize time in grading.

6. Analyze the results of the examination with a long range view of improving the examination, the course of study, and the efficiency of instruction and instructional material.

FIGURE 1

Type of Questions Making Up Final Examination

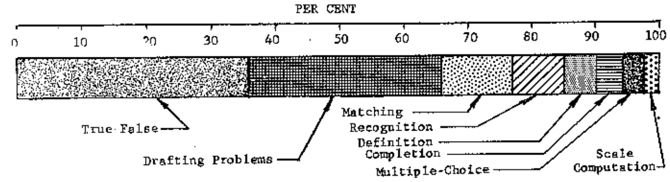


FIGURE 2

Relative Points Allotted To 15 Topics On An Early Form of Final Examination

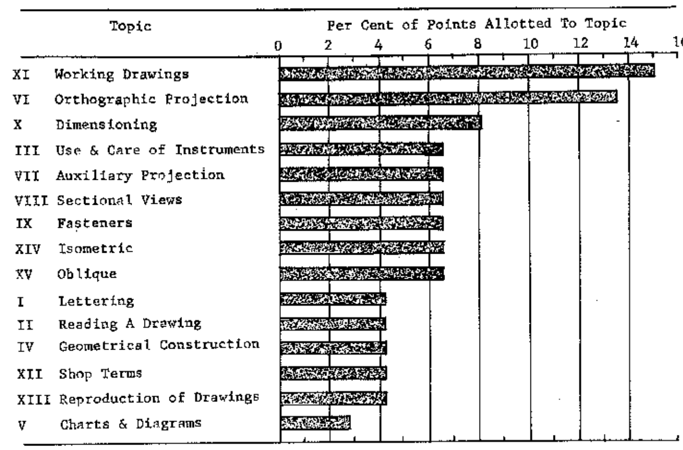


FIGURE 3

Comparison Of The Time Taken By 125 Students In 5 Classes To Complete The Final Examination

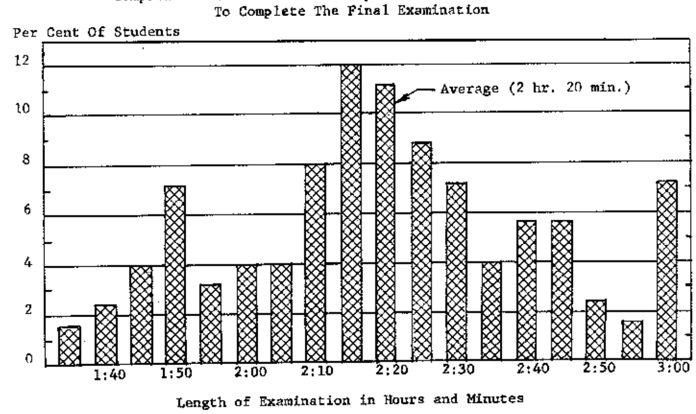


TABLE 1

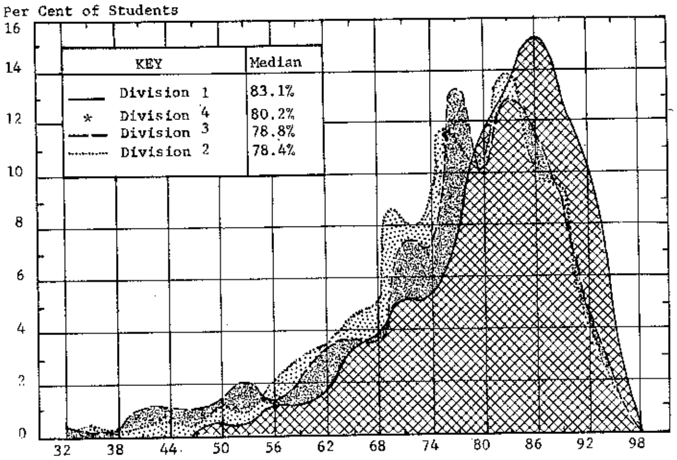
Comparison of the Central Tendency and Variability of Grades on the Final Examination

	Division 1	Division 2	Division 3	Division 4
Upper Limit	97%	97%	97%	95%
Lower Limit	47	30	34	59
Range	50	67	63	36
Arithmetic Mean	81.3	76.8	76.7	79.[illegible]
Quartile Deviation	6.5	7.0	7.0	5.4

FIGURE 4

Distribution Curves of Grades Made on Engineering Graphics Final Examination by 2268 Students of the University of Illinois

Per Cent of Students



Test Scores in Per Cent

* Insufficient Numbers to Graph

TABLE 2

Comparison of Number of Students and Size of Classes Taking Final Examination

	Division 1	Division 2	Division 3	Division 4	Total
Total No. of Students	708	762	798	89	2357
No. of Classes	35	38	41	3	117
Aver. No. Students	20.2	20.5	19.4	29.6	20.1
Largest Class	25	26	30	35	35
Smallest Class	16	16	5	22	5

FIGURE 5

Comparison of the Performance by One Division of the University on the Various Parts of the Examination

Profile Chart

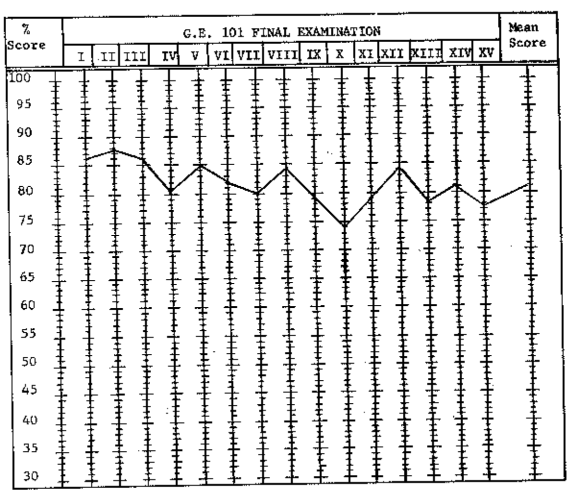


TABLE 3

Calculation of the Reliability Coefficient of the G.E. 101 Final Examination by the Method of Chance Halves

Pupil	X Odds	Y Evens	x'	y'	x'^2	y'^2	x'y'	Pupil	X Odds	Y Evens	x'	y'	x'^2	y'^2	x'y'
1	85	86	5	8	25	64	40	46	83	84	3	6	9	36	18
2	88	87	8	9	64	81	72	47	85	81	5	3	25	9	15
3	91	85	11	7	121	49	77	48	84	82	4	4	16	16	16
4	83	85	3	7	9	49	21	49	82	83	2	5	4	25	10
5	85	84	5	6	25	36	30	50	83	81	3	3	9	9	9
6	83	83	3	5	9	25	15	51	84	78	4	0	16	0	0
7	82	85	2	5	4	25	10	52	79	81	-1	3	1	9	-3
8	82	80	2	2	4	4	4	53	83	76	3	-2	9	4	-6
9	81	79	1	1	1	1	1	54	79	78	-1	0	1	0	0
10	82	76	2	-2	2	4	-4	55	80	77	0	-1	0	1	0
11	76	79	-4	1	16	1	-4	56	78	78	-2	0	4	0	0
12	79	77	-1	-1	1	1	1	57	81	77	1	-1	1	1	-1
13	77	76	-3	-2	9	4	6	58	79	78	-1	0	1	0	0
14	74	76	-6	-2	36	4	12	59	80	74	0	-4	0	16	0
15	75	72	-5	-6	25	36	30	60	74	80	-6	2	36	4	-12
16	70	77	-10	-1	100	1	10	61	79	72	-1	-6	1	36	6
17	69	74	-11	-4	121	16	44	62	74	70	-6	-8	36	64	48
18	73	64	-7	-14	49	196	98	63	65	57	-15	-21	225	441	315
19	69	65	-11	-13	121	169	143	64	55	64	25	-14	625	196	-350
20	67	66	-13	-12	169	144	156	65	74	69	-6	-9	36	81	54
21	55	59	-25	-19	625	361	475	66	87	86	7	8	49	64	56
22	87	89	7	11	49	121	77	67	58	58	-22	-20	464	400	440
23	88	82	8	4	64	16	32	68	79	75	-1	-3	1	9	3
24	85	82	5	4	25	16	20	69	79	83	-1	5	1	25	-5
25	83	85	3	7	9	49	21	70	67	59	-13	-19	169	361	247
26	86	80	6	2	36	4	12	71	82	85	2	7	4	49	14
27	83	80	3	2	9	4	6	72	62	63	-18	-15	324	225	270
28	83	78	3	0	9	0	0	73	81	71	1	-7	1	49	-7
29	84	79	4	1	16	1	4	74	81	79	1	1	1	1	1
30	81	78	1	0	1	0	0	75	86	86	6	8	36	64	48
31	76	80	-4	2	16	4	-8	76	79	80	-1	2	1	4	-2
32	79	78	-1	0	1	0	0	77	89	82	9	4	81	16	36
33	76	81	-4	3	16	9	-12	78	79	77	-1	-1	1	1	1
34	79	73	-1	-5	1	25	5	79	67	61	-13	-17	169	289	221
35	76	78	-4	0	16	0	0	80	77	71	-3	-7	9	49	21
36	78	73	-2	-5	4	25	10	81	74	71	-6	-7	36	49	42
37	73	76	-7	-2	49	4	14	82	81	78	1	0	1	0	0
38	72	74	-8	-4	64	16	32	83	79	82	-1	4	1	16	-4
39	72	72	-8	-6	64	36	48	84	83	85	3	7	9	49	21
40	70	66	-10	-12	100	144	120	85	77	70	-3	-8	9	64	24
41	69	66	-11	-12	121	144	132	86	85	79	5	1	25	1	5
42	67	65	-13	-13	169	169	169	87	81	82	1	4	1	16	4
43	66	57	-14	-21	196	441	294								
44	86	87	6	9	36	81	54								
45	87	83	7	5	49	25	35								
Σ (Sums)											-124	-122	3964	4300	3857
Guessed Mean									80	78					

$$r = \frac{\frac{\Sigma x'y'}{N} - \left(\frac{\Sigma x'}{N} \cdot \frac{\Sigma y'}{N}\right)}{\sqrt{\frac{\Sigma (x')^2}{N} - \left(\frac{\Sigma x'}{N}\right)^2} \cdot \sqrt{\frac{\Sigma (y')^2}{N} - \left(\frac{\Sigma y'}{N}\right)^2}} = \frac{\frac{3857}{87} - \left(\frac{-124}{87} \cdot \frac{-122}{87}\right)}{\sqrt{\frac{3964}{87} - \left(\frac{-124}{87}\right)^2} \cdot \sqrt{\frac{4300}{87} - \left(\frac{-122}{87}\right)^2}} = .93/3$$

$r = .9313$, reliability coefficient for either half of the examination

Estimated r of the Entire Examination by use of the Spearman-Brown prophecy formula. $r_{nn} = \frac{nr}{1+(n-1)r} = \frac{2(.9313)}{1+(2-1).9313}$ $r_{nn} = .964$

PRELIMINARY PROGRAM FOR THE MID-WINTER MEETING OF THE ENGINEERING GRAPHICS DIVISION

JANUARY 17, 18, 19, 1962

January 17 (Wednesday)

5-10 P.M.	Registration	
6:30-9:30	Executive Committee and Invited Guests Dinner and meeting	

January 18 (Thursday)

8-9 A. M.	Registration	
9-9:20 A. M.	Opening Session	
	1. Greetings from the University and College	Kurt F. Wendt, Dean, College of Engineering
	2. Response	Edward M. Griswold, Chmn, Div of Engineering Graphics
9:20-12 A. M.	Technical Session - Modern Teaching Techniques	
	1. Evaluation & Demonstration of the Use of the Overhead Projector in Teaching Graphics	Prof. Clayton Chance, University of Texas
	2. A Teacher Training Program in Chalkboard Techniques	Prof. Eugene Pare, Washington State Univ.
	3. The Teaching Machine & Its Application to the Teaching of Graphics	Prof. M. N. Besel and E. W. Knoblock, Univ. of Wis.-Milwaukee
12:15-1:15 P. M.	Luncheon	
1:30 P. M.	Group Picture	
2-5 P. M.	Technical Session Subject: The Impact of the Computer on Engineering Graphics	
	1. The Electronic Computer -- Giant Brain or Giant Moron?	Prof. C.H. Davidson, Director, Engineering Computing Laboratory, University of Wisconsin
	2. Numerical Control and Graphics	R.G. Chamberlain, Standards Engineer, Giddings & Lewis Machine Tool Co.
	3. Mechanization of Engineering Design Data	D.L. Kilcrease, Engineering Services Manager, International Business Machines
6:30-10 P. M.	Annual Banquet Presiding: E.M. Griswold, Chmn, Engineering Graphics Division	Speaker: Professor Menahem Mansoor, Chmn. Dept. of Hebrew and Semitic Studies "The Challenge of the Dead Sea Scrolls"
	Social Hour	

January 19 (Friday)

8-9 A. M.	Technical Session	
9-12 A. M.	Subject: The Future Course of Engineering Graphics	
	1. From the Faculty Viewpoint	Professor Stephen M. Coons, Massachusetts Institute of Technology
	2. From the College Administrator's Viewpoint	Dean Jasper Gerardi, University of Detroit
	3. From Industry's Viewpoint	Ed Woerter, Standards Administrator, American Machine & Foundry Company F. P. Esty, Vice President & Chief Engineer, Wisconsin Motors Corporation
12:15-1:30 P. M.	Luncheon & Business Meeting	Presiding: E. M. Griswold, Chairman
2-4:30 P. M.	Inspection Tours 1. Forest Products Laboratory 2. S.A.G.E. - Truax Field, U.S.A.F. (Semi-automatic Air-Ground Environment)	
5:00 P. M.	Adjournment	

A Ladies Program is being arranged and will be included in the final program.

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AN APPLICATION FOR THE MÖBIUS BAND

Paul Calcaterra, Engineer
Kollsman Instrument Corp.

Another practical use has been found for the Möbius band, the well-known surface which was named for the German mathematician, August Ferdinand Möbius, who studied its properties about a century ago. This surface may be formed by taking a long strip of thin material, giving one end a half-twist, and joining it to the other end as in Fig. 1. The strip, instead of having two sides as before joining, now has only one "side." Thus, if the surface is traversed in either direction, you will return to the starting point after traversing the entire surface of the strip excluding, of course, the edge.

A previous application of this property of the Möbius band was a conveyor for hot material patented in 1957 (Pat.No.2,784,834). The conveyor belt, formed with a half-twist, presents alternate "sides" to the hot material, thereby allowing a longer cooling time for each point on the belt.

A certain class of indicating instruments presents information by means of a graduated tape which moves past a fixed pointer. The application of the Möbius band is obvious. By forming the tape with a half-twist and placing graduations and numerals successively along both "sides" of the tape, as in Fig. 2, a tape only half as long as the conventional type is needed for a given graduation spacing and scale length. With the present trend towards miniaturization, the space and weight savings can be significant.

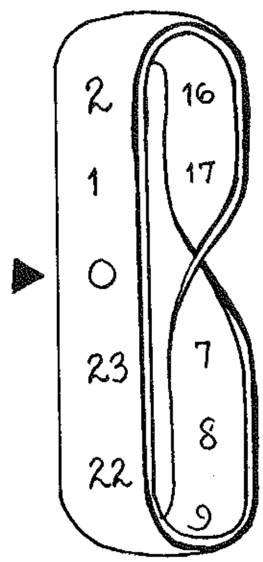


Figure 2.

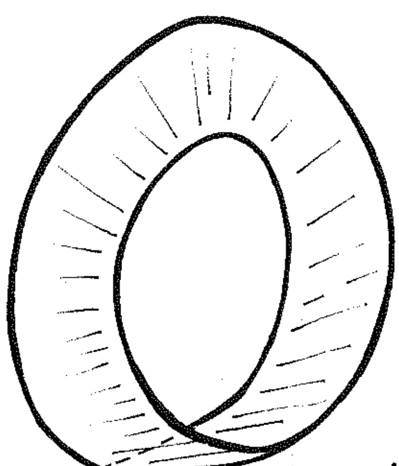
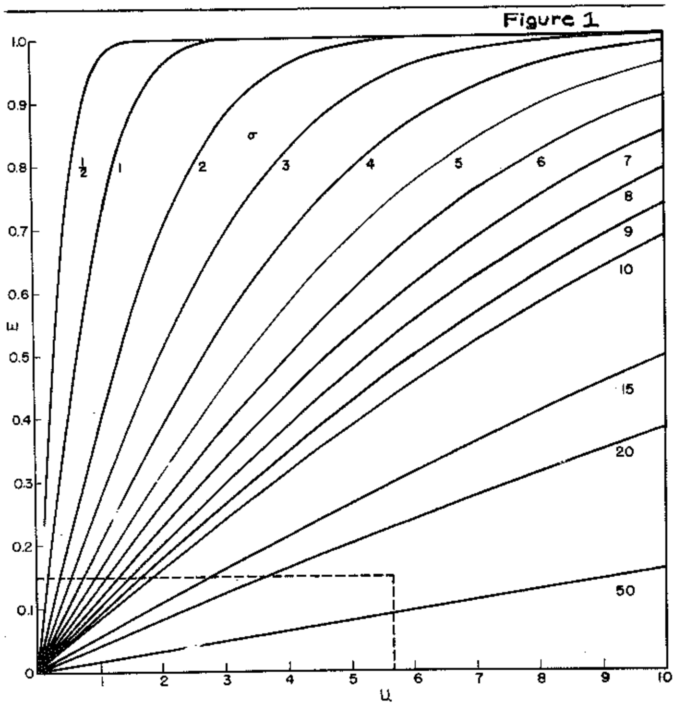


Figure 1.

ON THE NON-PROJECTIVE TRANSFORMATIONS OF A NOMOGRAM

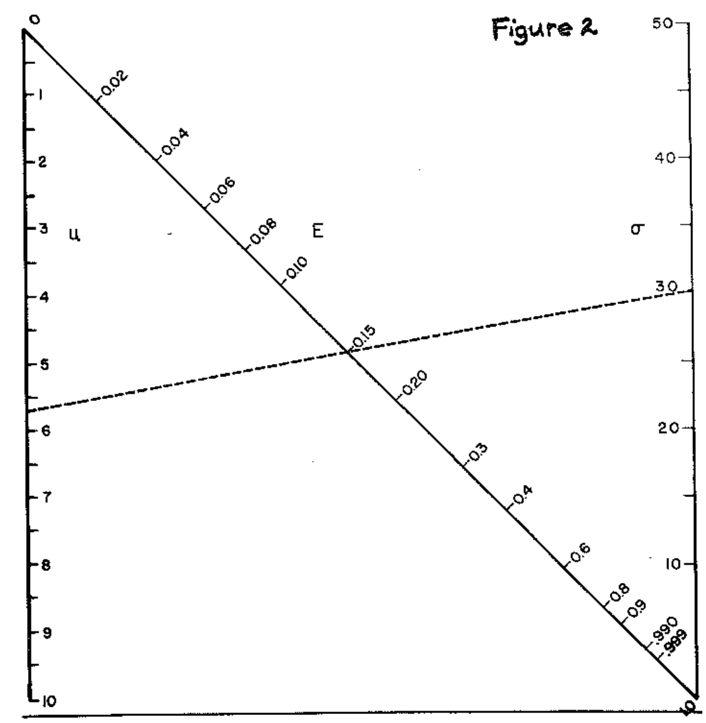
By L. Ivan Epstein, Lowell Technological Institute, Lowell, Massachusetts

Functions of two variables are frequently encountered in engineering calculations. To facilitate their rapid evaluation by persons untrained in mathematics, graphical devices are commonly used. These usually take the form of a family of curves as shown in Fig. 1. Here, one of the independent variables is plotted as the abscissa, and the other is the parameter which determines the choice of the curve. The dependent variable is then the ordinate. (The detailed description of the figures begins in the third paragraph.) Alternatively, it is frequently possible to represent such a function by a nomogram. This consists of three scales (see Fig. 2), each of which



represents one of the variables. A straight edge laid across the diagram (for instance the dotted line) intersects the three scales in three points whose corresponding scale values are related by the formula represented by the nomogram. When construction of a nomogram is possible, it possesses the advantage that the nomogram is capable of a great variety of projective transformations. These will be found described in textbooks of nomography.(1) By this means, the nomogram can always be transformed in such a manner that the useful portion of each scale runs the length or width of the page, so that we can always attain the highest accuracy compatible with available page space. Another advantage of a nomogram is that all three variables are represented by scales, so that the awkward task of interpolating visually between curves such as those of Fig. 1 is avoided.

In the simplest and most common case where the nomogram consists of three rectilinear scales, non-projective transformations are possible in addition to the projective transformations. The latter are well known. But while the former have long been known to mathematicians,(1,2) they have received surprisingly little attention from practical nomographers. The present paper is intended to draw attention to the practical value of these non-projective transformations and to illustrate it with a few examples. It will be seen that the combination of the two kinds of transformations will enable us to magnify selectively that part of the useful portion of one scale where the highest accuracy is required.



The illustrative example used throughout this paper is the error function. This is defined by the equation

$$E = \frac{1}{\sigma\sqrt{2\pi}} \int_{\bar{x}-u}^{\bar{x}+u} \exp\left[-\tfrac{1}{2}\left(\frac{x-\bar{x}}{\sigma}\right)^2\right] dx,$$

where x is a variable which follows a normal probability distribution, x is the mean value of x, and the standard deviation of x from the mean is denoted by σ, so that E is the probability that x will differ from $\bar{x}$ by no more than u in either direction. Thus, given $\sigma = 30$ and $u = 5.68$, we find from Fig. 1 that $E = 0.150$, as indicated by the dotted lines. Unfortunately, the value of σ used here falls between the values for two of the curves, and accurate interpolation is likely to prove difficult.

Fig. 2 shows one of the most elementary types of nomogram, the so-called N chart. The dotted line shows that position of the straight edge which relates the same numerical values of the three variables as the dotted lines in Fig. 1. Now the σ scale is no more difficult to read than the other two scales. In this example, we have shown values of σ ranging from 1 to 50, and values of u ranging from 0 to 10. Any other desired scale portions could have been made to run the length of the available page space by means of a projective transformation. By the same means, we can always place the answer scale between the two data scales, so that any two values of the independent variables shown in the diagram will always correspond to a value of the dependent variable which is likewise within the bounds of the diagram. Thus the danger of running off the scale is avoided.

Since the nomograms reproduced herewith are rather numerous and are only intended as illustrative examples, the fine scale graduations have been omitted, and the nomograms have been reduced to a small size. If each nomogram were made to fill a page, and if more fine graduations were entered, the scales could be read with a much higher accuracy. This addition of finer graduations is far less time-consuming than the addition of more curves to a diagram such as Fig. 1.

Probably the best known type of nomogram consists of three parallel scales. The scales for u and σ would then be logarithmic. Since this type of nomogram is so well known, we shall omit its illustration here.

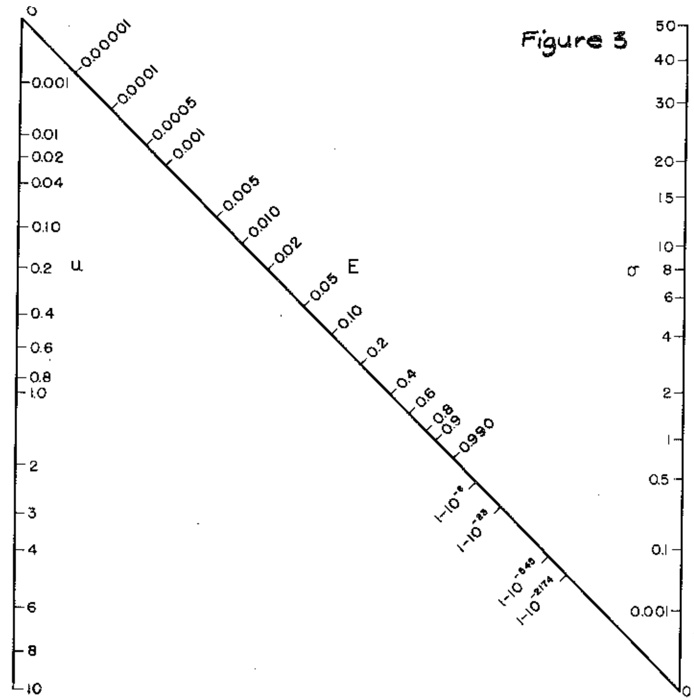
In constructing Fig. 2, we have started out in essence by constructing the familiar N chart for the equation $A = u/\sigma$. Now E is actually a function of the single variable A. We have therefore replaced the values on the A scale with the corresponding values of E. Now we can subject Fig. 2 to a non-projective transformation by constructing an N chart for the equation

$$A^a = u^a/\sigma^a, \qquad (1)$$

so that A^a, u^a and σ^a respectively take the places of A, u and σ in the method of construction of the nomogram. The graduations on the A scale are then marked with the corresponding values of E as before. Each value of a yields a different nomogram. Both positive and negative values of a are useful. They may be greater than 1, or they may be proper fractions. The reader may experiment with these to discover the particular advantages of each. The example a = 0.25 is illustrated in Fig. 3. Note that it magnifies those portions of the E scale where values of E are greater than 0.90 or less than 0.02.

The equation

$$B^2 - kB + f = 0 \qquad (2)$$



can be nomographed by elementary methods. Given k and f, we obtain two values of B, which we shall denote by B_1 and B_2. Now we have $k = B_1 + B_2$. Omitting the f scale, we write

$$B_1 = \log_{10} u, \qquad (3)$$

$$B_2 = -\log_{10} \sigma, \qquad (4)$$

$$k = \log_{10} A. \qquad (5)$$

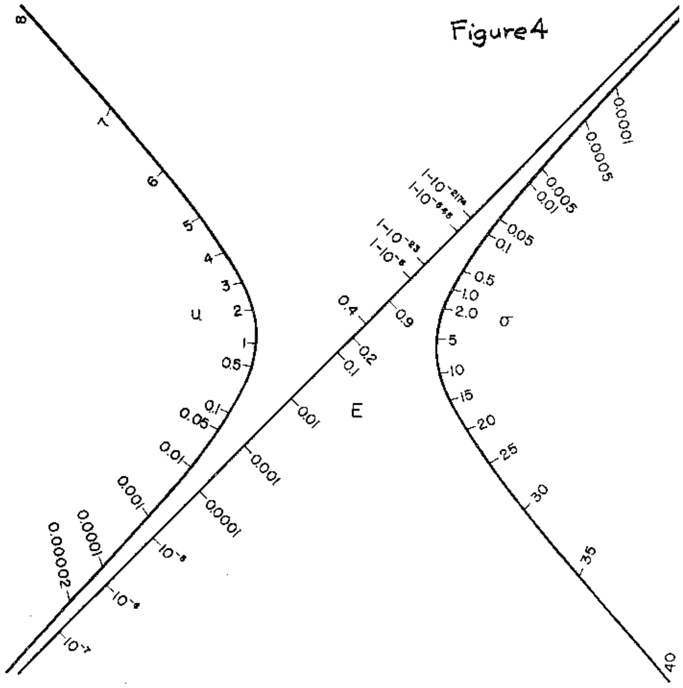
We now obtain a nomogram in which the scales for u and σ coincide. If we now replace u, σ, and A respectively with gu, hσ, and gA/h, we can usually choose the parameters g and h in such a manner that the useful portions of the u and σ scales do not overlap. These now fall on a conic section, and by a projective transformation they may be transformed into two branches of a hyperbola. The example g = 1/11, h = 1/55 is illustrated in Fig. 4. By assigning other values to g and h, we obtain an endless variety of non-projective transformations. Only in the special case where h = 1/g do we obtain a projective transformation. Since the proof is of purely theoretical interest, it will be omitted here.

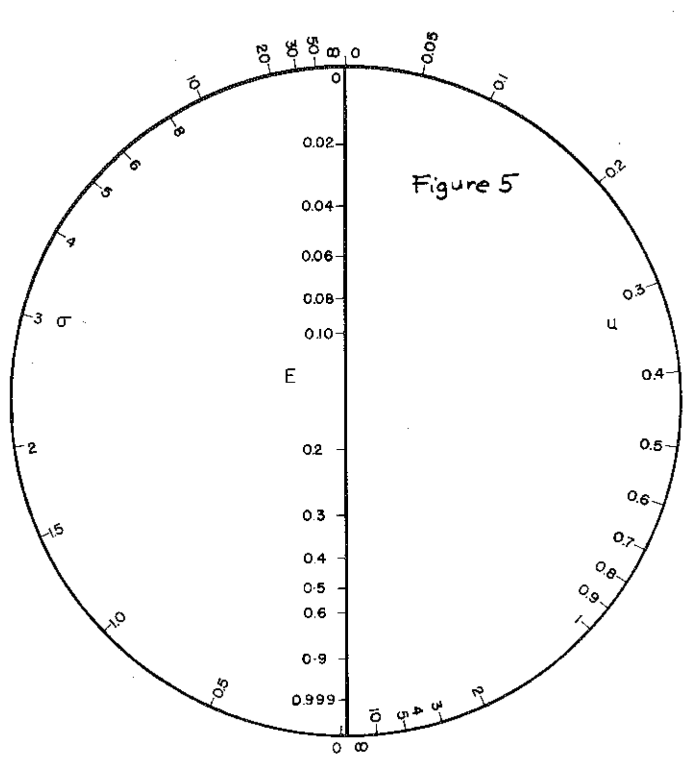
The transformation of Eq. (1) is also projective in this case.

The two solutions B_1 and B_2 of Eq. (2) satisfy the equation

$$f = B_1 B_2. \qquad (6)$$

Hence, if Eq. (2) is nomographed and the k scale omitted, we obtain another nomogram for multipli-





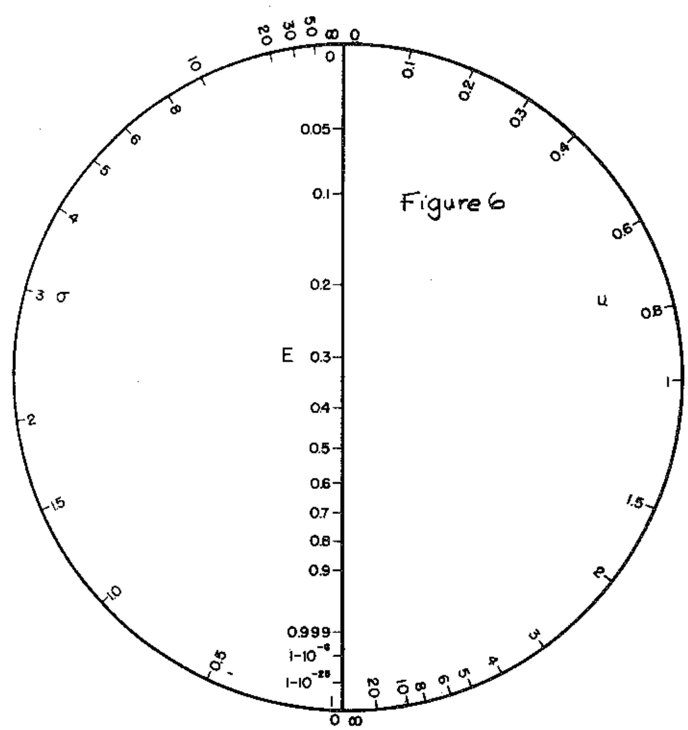
cation. Let B_1, B_2 and f be replaced with u, $-1/\sigma$, and −A respectively. The result (transformed by projection as usually) is shown in Fig. 5. The scales for u and σ now cover the whole range of values from zero to infinity. But since the graduations on both these scales crowd very close together when u or σ becomes very large, the useful ranges are finite. Note however that these scales can be made to cover a narrow but frequently used range of values with a high accuracy while allowing the rarely used remainder of a much wider range of values be covered with a correspondingly lower accuracy at the same time. We now come to the means whereby we can control the positioning of these ranges.

We have previously used the generalized formula

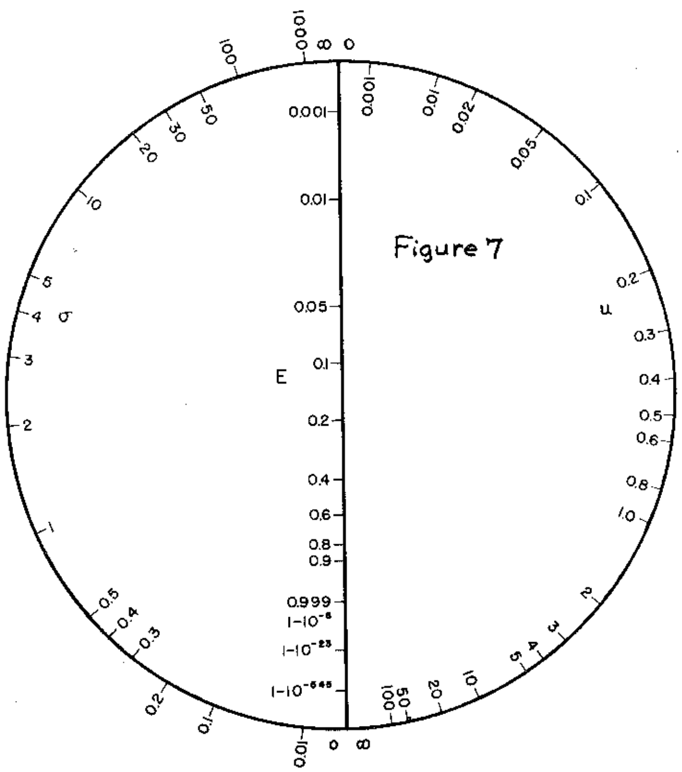
$$\left(\frac{gu}{h\sigma}\right)^a = \left(\frac{g}{h}A\right)^a,$$

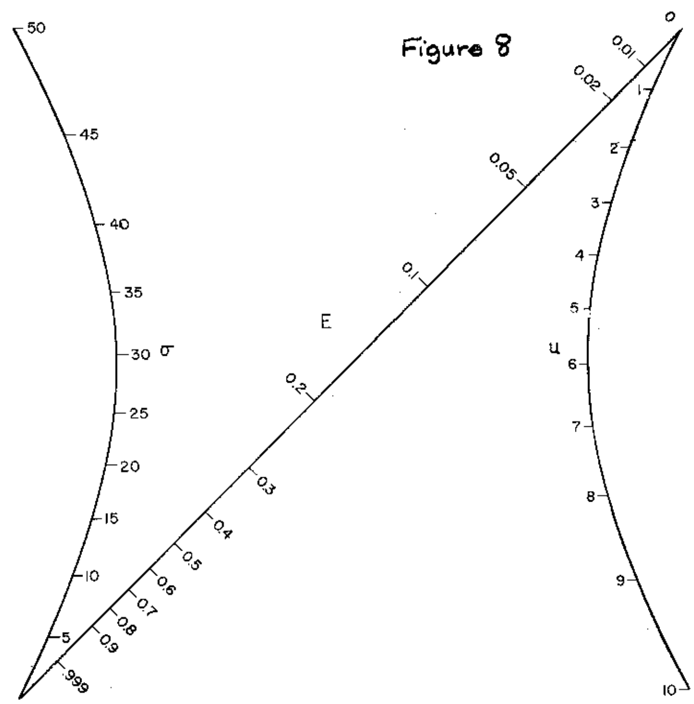
so that u, σ, and A are replaced with $(gu)^a$, $(h\sigma)a$, and $(gA/h)^a$ respectively, where g, h and a are constant parameters. For each choice of these parameters, we obtain another type of nomogram. Only if $h = 1/g$ and $a = 1$ is the transformation projective. Again the proof will be omitted. In Fig. 5 we had the initial state $g = h = a = 1$, transformed by projection. In Fig. 6 we have the case $g = 1$, $h = 1/2.3$, $a = 1$. Note that we now have more room for some additional graduations on the u scale for values greater than 10. In Fig. 7 we have the case $g = 2.3$, $h = 1/2.3$, $a = 0.5$. As compared to Fig. 5, this means a contraction of the middle portion of each scale and magnification of the portions for large and small values.

The type of transformation illustrated in Figs. 6 and 7 has the unusual property that a meaningful nomogram is obtained even if g and h are imaginary numbers. Fig. 8 illustrates the case $a = 1$, $g = 0.07071i$, $h = 0.0141421i$.



The few examples given here may suffice to illustrate the practical value of these non-projective transformations. Numerous other non-projective transformations are possible. For instance, in any one of Figs. 4 through 8, we may interchange A with either σ or 1/u, so that the E scale becomes curved and one of the other scales becomes a straight line. A projective transformation will then restore the E scale to its preferred place between the u and σ scales. Still other types of non-projective transformations will be found in the references cited.





(1) L. I. Epstein: Nomography (Interscience Publishers, 1958)

(2) T. H. Gronwall, Journal des Mathematiques Pures et Appliquees, Ser.6, Vol 8,pp.59-102 (1912)

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Inter-Disciplinary

C. J. Baer, University of Kansas
S. A. Coons, Massachusetts Institute of Technology
W. H. Eubanks, Mississippi State University
L. G. Palmer, University of Minnesota
P. M. Reinhard, University of Detroit, Co-chairman
S. M. Slaby, Princeton University, Co-chairman
E. R. Weidhaas, Pennsylvania State University

Educational Relations

S. C. Allen, Michigan College of Mining & Technology
E. C. Bergmann, Michigan State University
A. L. Bigelow, Princeton University
R. S. Lang, Northeastern University
M. G. Mochel, Clarkson College of Technology
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E. C. Zulauf, University of Detroit

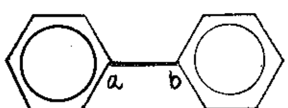
CHEMISTRY AND GEOMETRY

By Leonard Kaplan

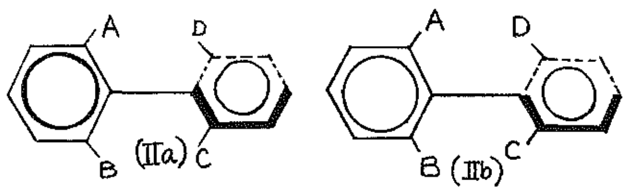
(CONTRIBUTION FROM THE NOYES CHEMICAL LABORATORY, UNIVERSITY OF ILLINOIS)

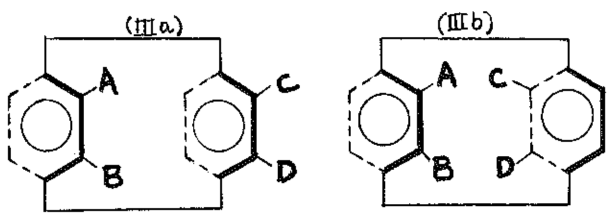
An ability to use graphical methods to solve geometrical problems would be a great asset to a chemist, since geometrical factors greatly affect the structure and reactivity of chemical compounds. The use of geometry to explain chemical observations has been increasing quite rapidly, as chemists have been realizing the critical importance of molecular geometry. As this use evolves from the pictorial to the analytic and mathematical stage, a knowledge of the techniques of descriptive geometry will become of greater and greater importance. The following simple examples should serve as illustrations of typical geometrical problems a chemist might encounter.

A single bond uniting two atoms is such that in the great majority of cases, there is little hindrance to free rotation about it. For example, in biphenyl(I) there is free rotation about the bond (line ab) joining the two rings. However, if certain bulky groups are substituted onto the two rings, these groups will "bump" into each other as the rings are rotated and hence prevent free rotation. In such a case, two different, separable compounds (IIa,IIb) are formed.

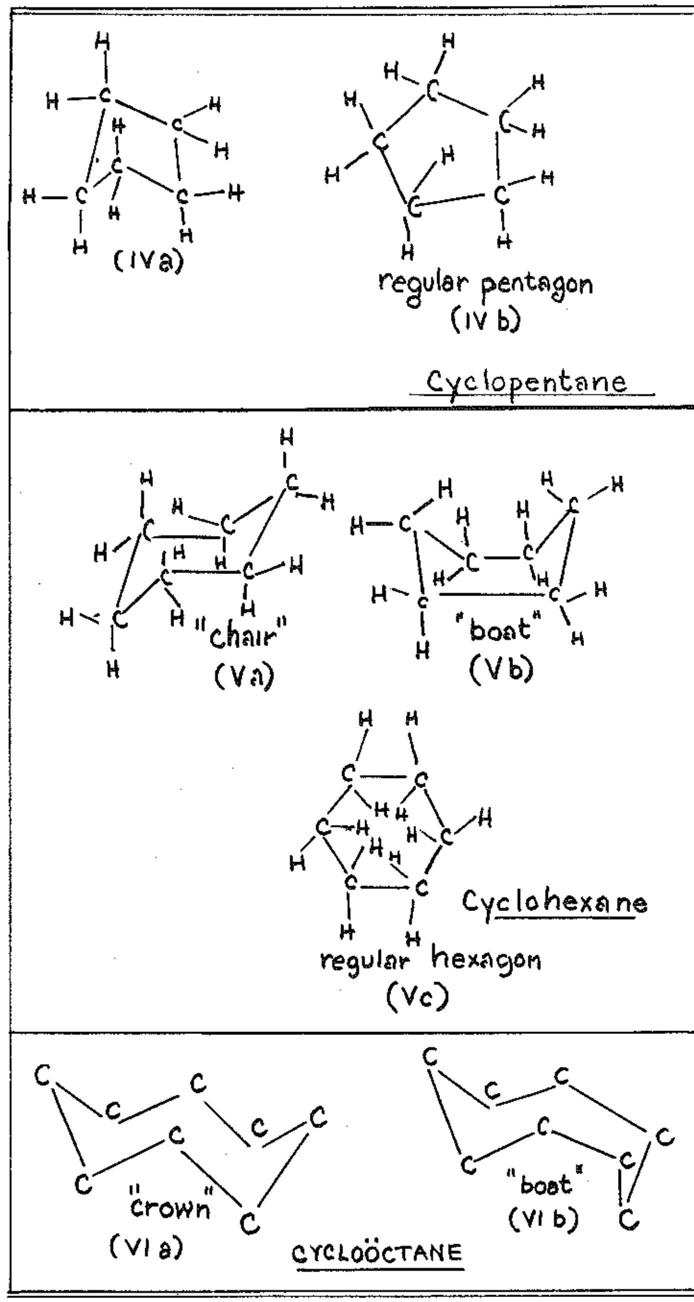


(1)



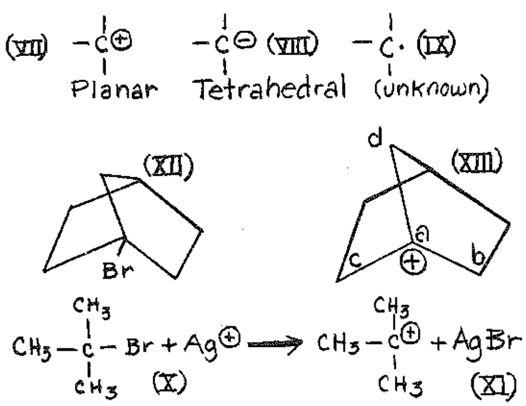


Groups A, B, C and D can have almost any shape. In order to predict whether or not certain combinations of groups will "bump" into each other, chemists have traditionally resorted to constructing expensive models of the compounds. This is a problem which can easily be solved by use of elementary techniques of descriptive geometry. A similar problem, which has been considered quite recently concerns the paracyclophane series, an example of which is shown.



The geometrical conformation in which certain cyclic organic compounds exist has been and continues to be the subject of much chemical investigation. Consider the following two compounds. Each compound could conceivably exist in any of the conformations shown. However, conformation "a" is favored in each case. One factor which determines this is the degree of interference (repulsion) between the hydrogen atoms. Qualitatively, it is seen that such interference is least in compound "a" of each series. However, such a decision is no longer an easy one as the number of atoms in the ring is increased. For example, which of the two (of several) possible conformations of cyclooctane (VIa,VIb) would be favored? (The angle between any three bonded atoms can be considered to be 109°28'.) A preliminary answer to such a question could be obtained through use of methods of descriptive geometry.

Geometrical configuration lies at the heart of any discussion of chemical reactivity. A carbonium ion (VII), carbanion (VIII), or free radical (IX) is often formed in the course of a chemical reaction. If one of these must be form-



ed in order that a given reaction may take place, the speed with which the reaction occurs depends upon the ease with which the compound can attain the necessary configuration. Consider the following reaction sequence. Tertiary butyl bromide (X) will react readily with silver ion, since the tertiary butyl system can easily attain a planar configuration and hence form the carbonium ion (XI). However, 1-bromobicyclo-(2.2.1)heptane (XII) will not undergo this reaction when treated with Ag^+ for 1 hour at 100°C since it is extremely difficult for the necessary carbonium ion (XIII) to form. This would require points a, b, c and d to be coplanar, which cannot occur without straining the rest of the molecule. In order to predict whether a reaction such as this would occur, one would have to know what distortions in bond lengths and bond angles would be necessary in order for the molecule to become planar. This problem could be attacked through the methods of descriptive geometry.

These have been but three of the vast number of instances in which chemical questions could be attacked as problems in geometry. Therefore, it is more important now than ever before that a chemistry student realize that the use of descriptive geometry is available as a possible mode of attack on his problems and that he have knowledge of how to use it.

INTERNATIONAL CONFERENCE ON SPACE GEOMETRY

SPACE GEOMETRY is the subject of a conference which is projected to be held at Princeton University, August 19 to 24, 1963.

If you are interested in either attending or participating write Professor Steve M. Slaby, Chairman, Department of Graphics and Engineering Drawing, Princeton, New Jersey. It should be noted that the holding of the Conference is conditional, depending on whether or not necessary funds to finance activities are obtained. Following is the information available at the present time.

Date: August 19 to 24, 1963.

Place: Princeton University, Princeton, New Jersey.

Purpose: To bring together leading men in the field of Space and Descriptive Geometry and allied fields, to present and to discuss recent developments of the science and its theoretical and practical application to present day engineering and scientific problems.

Conferees: Professors and colleagues from universities and technical schools, and research institutions and industry from abroad and from the United States. We would welcome colleagues from all the fields of engineering, and those in mathematics and physics, who are interested in our field. We should like two representatives from each country. We plan on an approximately equal number of qualified persons from American universities and research, so that every foreign guest would be in the personal charge of an American colleague.

Participation: It is planned that there will be at least two to four papers presented per day, followed by open discussion. The papers will be published and bound in book form, for later distribution.

Travel costs, expenses: We are endeavoring to interest educational foundations in covering the cost of travel and sojourn of the participants.

ENGINEERING GRAPHICS COURSE CONTENT DEVELOPMENT STUDY

The National Science Foundation has awarded the University of Detroit a grant of $68,000 for a two year project to study the course content of engineering graphics in engineering education. The results of this project should strengthen the role graphics plays in a scientific oriented engineering curriculum. Professor Paul M. Reinhard, Chairman of the Dept. of Engineering Graphics, University of Detroit, Detroit, Michigan is director of the project and may be contacted for further information. The objectives and participants in the study are as follows:

General objective

To contribute to the improvement of engineering education through an investigation of the place of graphics in communication of information, solution of complex problems, and analysis in contemporary and future engineering research and practice and through the development, review, trial and publication of new materials for inclusion in engineering courses and related disciplines in scientifically oriented curricula.

Specific objectives

1. To investigate the place of engineering graphics in modern engineering study, research and practices;
2. To gather and develop new material suitable for use in appropriate courses in various engineering subjects;
3. To test and evaluate materials;
4. To prepare reports which will make the materials available to all engineering educators.

Direction

1. The study will be carried out under the general direction of an advisory committee of outstanding engineers in various fields, drawn from universities and industry.
2. The study will be led by a core committee of leaders in engineering graphics, with a central headquarters at the University of Detroit, and additional regional offices at Princeton University and the University of California at Berkeley; highly qualified scientists, engineers in universities and industry and other appropriate individuals and organizations will cooperate in developing and testing materials.

Reports

The director will submit reports to the Foundation on a schedule to be agreed upon as the study proceeds, including periodic progress and fiscal reports. A final report will be prepared at the end of the grant period giving a general synopsis of the results of the study, the director's evaluation thereof, and a summary of all expenditures.

Project Director

Professor Paul M. Reinhard
Chairman of the Engineering Graphics Department, University of Detroit

Associate Directors

Frank A. Heacock
Professor of Graphics - Emeritus
Princeton University

Alexander S. Levens
Professor of Mechanical Engineering
University of California at Berkeley

Core Committee

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Assistant Dean of Engineering
University of Detroit

Lt. Col. Robert H. Hammond
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United States Military Academy

Carson P. Buck
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Syracuse University

Lewis G. Palmer
Assistant Professor of Mechanical Engineering
University of Minnesota

Matthew McNeary
Professor and Head of the Engineering Graphics Department, University of Maine

Note:
The Project and Associate Directors are members of the "Core" Committee.

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University of Kansas

Dr. L. Coleman Knight, Head
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Muskingum College

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Senior Applications Analyst
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Dr. Newman A. Hall, Chairman
Department of Mechanical Engineering
Yale University

Dr. C. A. Whitmer, Head
Course Content Improvement Section
National Science Foundation
Washington, D. C.

GRAPHICS DIVISION AWARDS

This year there will be two awards by the Graphics Division. These awards will be given to the authors of the articles on the subjects which are judged by the two award committees. Chairmen of these committees are:

Nomography Award -- Professor R. G. Huzarski, University of New Mexico
Descriptive Geometry Award -- Professor J. S. Dobrovolny, University of Illinois

The Descriptive Geometry Award, which will be given for the first time in June 1962, is possible because of the donation of $100 by Frank Oppenheimer of the Gramercy Guild. For news about the Nomography Award, see the article in this issue about the 1960-61 Awards.

Readers may assist these award committees by bringing worthy articles to the attention of the Award Committees. The Descriptive Geometry Award Committee announces the following procedures which will be used this year in making the Award:

1. The articles should include Descriptive Geometry in the solution of a problem or it should be an article on Descriptive Geometry.
2. The article must have been published in a periodical.
3. The article must have appeared in an issue between the dates of January 1961 and December 1961, inclusive.
4. The use of Descriptive Geometry must be an important feature of the article.
5. The article must be brought to the attention of the Committee. The Committee will naturally search diligently for such articles but it is not responsible for finding all such articles.
6. The article will be judged on the originality, resourcefulness, effectiveness and its use of Descriptive Geometry. The drafting and the use of drafting aids, etc., should be competent, but are secondary considerations. Good quality sketches would be acceptable.
7. A majority of the committee votes received will determine the winner.
8. The winner will be announced at the Annual Dinner in June and the award will be made at that time.

RESULTS OF MECHANICAL DRAWING STUDY

Donald P. Hoagland, Industrial Arts Dept., West Essex Regional School District, West Caldwell, N.J.

A total of thirty-four colleges and universities offering a degree in engineering were contacted. All New Jersey colleges were included and quite a few from New York and Pennsylvania. The others were picked either by geographical location or by reputation and ranged from Florida to Massachusetts, and as far west as California.

Twenty-five replies were received and from them the following data was compiled.

Section I

While 92% of the colleges replying have no entrance requirements in mechanical drawing, 8% required one year.

The majority of the replies included the comment that they would prefer all entrants to have had mechanical drawing in high school, and Penn. State is at present studying the possibility of creating such a requirement.

Section 2

Although 16% indicated they do not recommend high school mechanical drawing, 76% recommend at least one year. Georgia Institute of Technology recommends at least two years.

One reply stated that although high school mechanical drawing is not required, such experience is desirable for entering students. The comment was made on one questionnaire that "some experience in graphical presentation is desirable for anyone."

Section 3

Areas recommended for coverage by high school courses:

all areas	36%
orthographic projection	52%
machine drawing	28%
descriptive geometry	36%
intersections and developments	20%
electrical drawing	0
lettering	40%
dimensioning	40%
pictorial representation	32%
architectural drawing	8%
applied geometry	28%
graphing	20%

Out of the twelve areas listed above, seven are included in the present program at West Essex High School. They are: orthographic projection, machine drawing, intersections and developments, lettering, dimensioning, pictorial representation and architectural drawing. It should be noted that the areas of intersections and developments, lettering and pictorial representation are not covered extensively.

Additional comments of interest:

"Any high school experience in lettering, machine drawing, dimensioning, applied geometry and graphing . . . has value." (Pratt Institute)

"We would recommend that those going into Engineering and Science complete mechanical drawing with emphasis on descriptive and applied geometry." (Carnegie Institute of Technology)

Name ______ Title ______

College or University ______ Date ______

The following questions are in reference to students applying for admission to your institution and majoring in an area of engineering or science. Space for comment is provided, if you so desire.

1. We require high school credit in mechanical drawing. __ No __1 yr __ 2yr __3 yr __4 yr.
   Comment ______
2. We recommend that students have high school credit in mechanical drawing.
   __No __1 yr __2 yr __3 yr __4 yr.
   Comment ______
3. We feel that the following general areas of mechanical drawing provide the best foundation for the entering student:

___orthographic projection	___all areas	___ graphing
___descriptive geometry	___intersections and developments	___ lettering
___machine drawing	___electrical drawing	___ dimensioning
___pictorial representation	___architectural drawing	___ applied geometry

Comments: ______

Please return to: Donald P. Hoagland, West Essex High School, Box 885, West Caldwell, New Jersey.

BRINGING ELECTRONICS INTO ENGINEERING GRAPHICS

By Harry Schwarzlander

INTRODUCTION

It seems that Engineering Graphics courses should be better integrated with the Engineering Curriculum than they are. Many students, unless they are going into machine design, group graphics courses along with Freshman English as chores that must be completed, but essentially unrelated to their future studies -- therefore, also quickly forgotten. How does this show up in their later work? They do not readily "see" a graphic picture in a physical situation or mathematical statement. When given a graphical representation of a physical process, they do not feel at ease in its manipulation and interpretation. Very rarely will a student resort to a graphical, rather than mathematical analysis in order to explore a new situation unless specifically instructed to do so.

Why not introduce principles of junior level engineering analysis by offering examples in freshman graphics courses, thus showing some applications of graphical constructions which the student will remember and which will free him of his inhibitions in using his graphic skills, besides giving him a small jump on things to come?

The analysis of a basic triode vacuum tube circuit is usually studied mathematically and graphically (2-dimensions) in Electronics courses. However, the 3-dimensional representation gives a clearer picture of tube operation and makes a simple descriptive geometry exercise. Since nowadays almost all engineering students get a smattering of electronics, this is not too specialized a topic to consider at the freshman level.

BACKGROUND

The only prerequisites needed are some statements about voltage, current and resistance.

The voltage, or electric potential, at a certain point is always expressed with respect to a certain reference point. The electric current is always expressed with respect to a reference direction. Fig. 1 shows a resistance R which is part of a circuit. Arrows are used to indicate

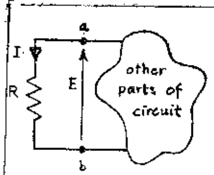


FIG. 1

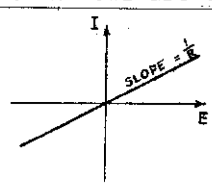


FIG. 2

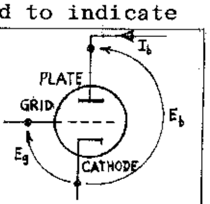


FIG. 3

that point a is at a potential E with respect to point b; and a current I flows from a to b through the resistance. With the two reference arrows in this relation to each other, we can now express Ohm's law by fig. 2; i.e., R= E/I.

Units are: R in kilohms (kΩ), E in volts (v), I in milliamperes (ma).

TRIODE CHARACTERISTICS

Associated with a triode vacuum tube are the three variables: grid voltage (E_g), plate voltage (E_b), and plate current (I_b) (Fig. 3). The relation between these variables, for a given tube type, is usually represented by a family of curves as in fig. 4 (dashed), which represent contour lines, parallel to the E_g=0 plane of a warped surface. In order to simplify analysis, the tube characteristics are often approximated by a "piece-wise linear" model (Fig. 4, solid lines) of equally spaced parallel lines, which in $E_gE_bI_b$- space represent the two plane segments shown in fig. 5. Incidentally, operation outside the octant shown in fig. 5 is usually not of interest.

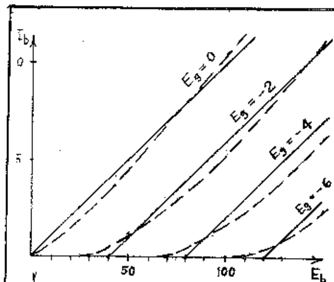


FIG. 4

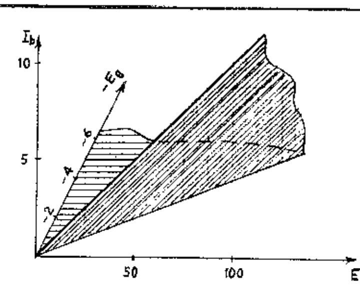


FIG. 5

OPERATING POINT

The tube can operate at any point in the surface of fig. 5. The actual operating point is determined by the nature of the electrical circuit external to the tube. It is found graphically as the intersection of the triode characteristic with the line that characterizes the external circuit.

A TRIVIAL EXAMPLE

The circuit in fig. 6 is trivial but convenient for introducing the circuit constraint line. The portion of the circuit external to the triode is made up of two batteries; one fixes E_b at 100 volts, the other fixes E_g at -2 volts. In $E_gE_bI_b$- space these conditions are represented by the planes E_b= 100 and E_g= -2 (Fig. 7). At their intersection both conditions are satisfied, effecting therefore the line representing the circuit constraints. This line intersects the triode characteristic at the point -2,100,6, the operating point for this example.

Note that one of the two planes in fig. 7, E_b= 100, describes the "plate circuit," i.e., the connection between plate and cathode, and the other one describes the "grid circuit," the connection between grid and cathode.

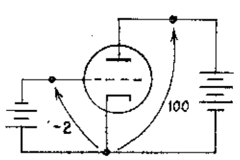


FIG. 6

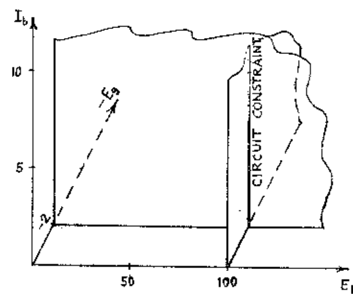


FIG. 7

BASIC TRIODE AMPLIFIER

In the configuration of fig. 8, the grid circuit is described as before by the plane $E_g = -2$. But in the plate circuit there is now added a resistance. Across the resistance exists a potential difference $E_L=I_bR_L$, which when added to E_b must equal 100v.

The plate circuit is again described by a plane -- since it is made up of linear elements -- and this plane is determined by any two lines in it, such as:

a) Consider $I_b=0$; then $E_L=0$ and $E_b=100$.

b) Consider $E_b=0$; then $E_L=100$ and $I_b=E_L/R_L=100/10=10$.

This plane is shown in fig. 9, and together with the grid circuit plane determines the circuit constraint line AB, which intersects the triode characteristic in the operating point -2,70,3, as is easily verified.

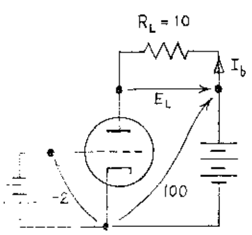


FIG. 8

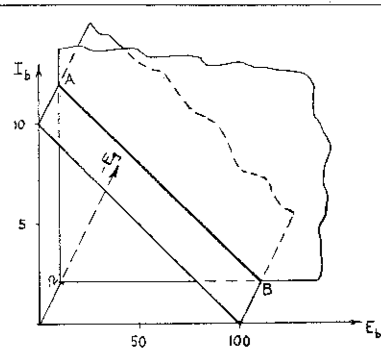


FIG. 9

TRIODE AMPLIFIER WITH CATHODE RESISTOR

While the above circuits were simple enough to be analyzed on a 2-dimensional plot such as fig. 4, this is not true for a typical practical circuit such as fig. 10. Here the grid voltage is produced by the current through the cathode resistor. This current is the same as the plate current, because no current flows in the grid. Therefore, $E_g=-E_k=-I_bR_k$. What is the operating point?

Starting with the plate circuit, the following two lines define a plane:

a) Let $I_b=0$; then $E_b=100$;

b) Let $E_b=0$; then $I_b=(E_L+E_k)/(R_L+R_k)=100/11=9.1$.

The grid circuit is now dependent on the plate current and the following defining lines can be used:

a) Let $I_b=0$; then $E_g=0$;

b) Let $I_b=5$; then $E_g = -5$.

The two planes are shown in fig. 11, and they determine the circuit constraint line CD. The intersection of CD with the triode characteristic plane is found by construction to be -2.4,73,2.4.

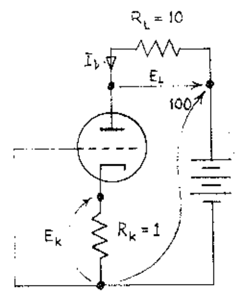


FIG. 10

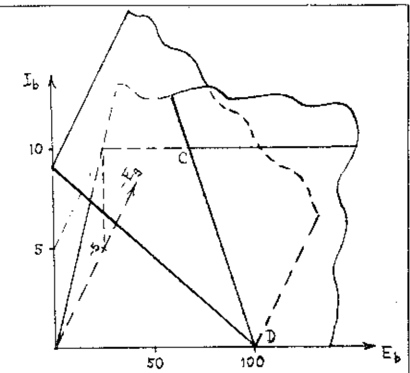


FIG. 11

ADDITIONAL USEFUL QUESTIONS

Location of the operating point is not the only question of interest. If small voltage fluctuation is superimposed (added) to the existing grid voltage, by some means, in any one of the above circuits, what happens to the plate voltage? Plate current? How far positive can such a fluctuation go before the operating point reaches $E_g=0$, in fig. 11 as compared to fig. 6 and 8? Before the operating point reaches $I_b=0$? The amplification, or "gain" of the circuit fig. 8 is the ratio of the change in plate voltage to the corresponding change in E_g. In fig. 10 the gain is $\Delta(E_b+E_k)/\Delta E_g$.

A problem in intersections of curved surfaces arises when the piecewise-linear approximation for the triode is not used, and a non-linear voltage-current relationship is defined for the resistances in the circuit.

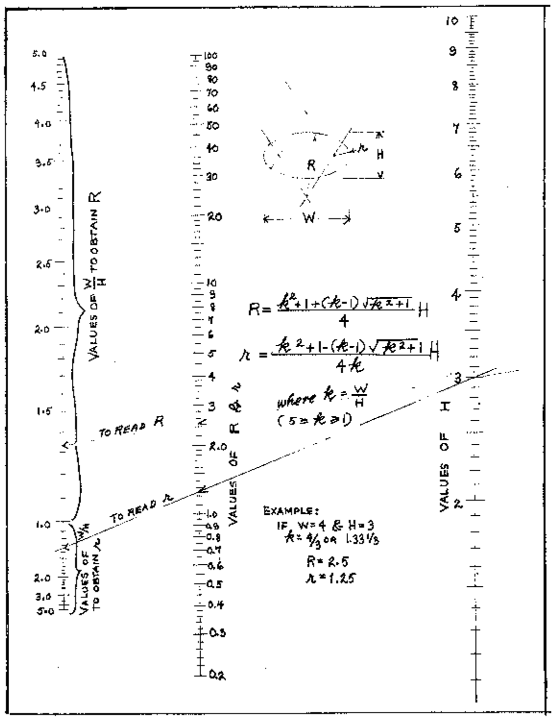
CONCLUSION

Triode vacuum tube circuits are an example of the kind of engineering topics that can be introduced in an elementary way in Graphics to make the student more application-conscious. Little time is needed to explain theory, and yet a wide range of practice problems can be given more meaning in this way.

NOMOGRAM FOR FOUR CENTERED ELLIPSE APPROXIMATION

By M. E. Arthur

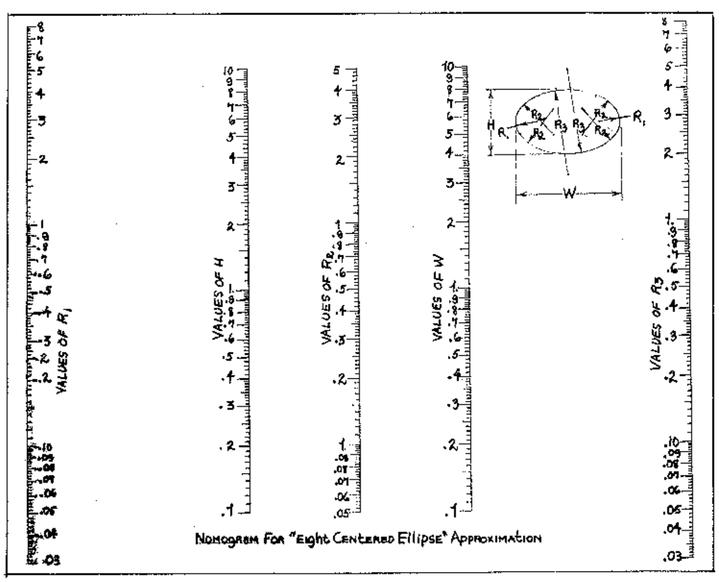
The attached nomogram is used to calculate the radii for constructing an approximation to an ellipse using arcs of circles. Although the approximation is not as pleasing to the eye as is a true ellipse, it is satisfactory for many purposes and ordinarily much faster to draw. Except for isometric drawings, the ellipse is seldom needed; consequently, the method of construction may be forgotten.



The nomogram offered here is based on one of the better construction methods and gives values for the radii, which are exactly those found by the construction for a given height (H) and width (W), where the width is greater than the height.

Referring to the attached nomogram, note that the values for H are on the right-hand scale and that the values for W/H are on the left-hand scale.

To obtain the required radii, place a straight-edge through the value of H and once through each appearance of the value W/H. For example, to obtain the required radii for an ellipse where W=4 and H=3, compute k=W/H or 4/3= 1.33 1/3. Place a straight-edge on the value of H on the right-hand scale, in this case 3, and draw a line from 3 to the values of W/H or 1.33 1/3 on the left-hand scale. Note that one line must be drawn for each appearance of the value W/H. Where the two lines cross the middle scale, the values of r and R can be obtained. In the above example, r=1.25 and R=2.5.



TEACHING CASE STUDY NO. I TEACHING TO DEVELOP IMAGINATION AND INVENTIVENESS

Kenneth E. Lofgren

Professor Lofgren, senior design professor at Cooper Union, has spent many years doing creative mechanical design work and teaching advanced courses in machine design. In this article he takes a look at the freshman drawing course and shows how to teach so that students are encouraged and stimulated to do creative design work.

Most engineering students do not know what the day-to-day work of the engineer is and this is a problem of excruciating seriousness. The incoming freshman, eager, alert and blissfully naive, comes to us with an image of the engineer hurled at him by countless newspaper headlines, magazine articles, and stories written by people who have almost zero technical knowledge and whose sole objective is to create dramatic reading. And if some writer, a bit more realistic than the others, paints a picture which is more factual, it is promptly blue-penciled by the editor, who snarls that this is not what the public wants to read. In consequence the dreams of the young men abound with visions which in few cases are realistic.

The student receives a rude jolt in his first few days in college. Instead of being immediately immersed in the concept of relativistic mechanics and other sophisticated ideas, he is given more drill problems in algebra and trigonometry, more tiring relations to learn by rote, dull vector force and equilibrium problems in physics, countless pages of chemical facts and formulas to study and in graphics he usually gets problems which have a minimum of mental challenge. He pauses for a moment in the breathless race to keep up with his assignments to ask: "Is <u>this</u> what engineering is?"

As a result, many are disillusioned and a serious number falter, drop out and are lost to us. Most of those who stay on are resentful, having the feeling that the college is not modern in its thinking. Engineers from industry tell us that even when our graduates approach their jobs directly after leaving school, the process of disillusionment must still be carried on. Ironically, even within the companies, there is a difference in the pictures painted by the ebullient recruiters and the more serious engineers who have the task of indoctrinating the young graduates.

What is the young engineer going to be asked to do? This question, of course, cannot be answered since special abilities, personality, and many other factors are involved. A fairer question is: What are these men expected to know? Let us briefly review the modern industrial picture, and since it is so popular (and so widespread) let's concentrate on space vehicles and missiles. Public notion to the contrary, only three or four out of a thousand engineering graduates, even after further degree work, will get into the select field of true basic research. A vastly larger percentage will work on research projects of a much more practical nature, such as developing more efficient nozzles for rocket engines, more dependable controls, etc. These men will be working with hardware and plumbing, heat transfer, stresses, metal fabrication, production problems, quality control, and DESIGN. And so, even as neophyte engineers, they are expected to have considerable knowledge of "things" which are to be made. They ought to know what metal is and what can be done with it, and they ought to know how to put things together. These problems involve creativeness of a high order. You do not solve the problem of packaging with a computer. What is needed is spatial visualization and an ability to put meaningful images down on paper with lines. A modern rocket engine comprises pumps, gear assemblies, valves and myriad other parts exquisitely designed, and the best of engineers are needed for this exciting work.

We who teach graphics have an opportunity to make an important contribution to the dual problem of helping to furnish industry with men able to meet these demands, and giving the young student his first taste of what engineering is like. Our work uniquely represents this type of engineering. Our graphics courses deal with things which make up engines and devices of all sorts. But, I believe that many graphic teachers need a re-orientation in their approach to this task. Nothing is more deadening than mere copying of something already designed. This need not be the objective sought however. Why not try to work into the problems the opportunity for the student to bring to his project some of his own creative ability? I speak from experience in this area and I can say that the students have convinced me, even freshmen, that they have a large amount of imagination and inventiveness. True, they know woefully little about the restrictions of manufacture, about what can and what cannot be done, but to tell the students about this makes the classes much more interesting to them and to the instructor. I confess that I am much more interested in getting the thrill of design across to the student than I am about the beauty of his linework or the perfection of his arcs and tangents.

What kind of problems can we give? They are already in the graphics textbook; all that needs to be done is to extend them a bit. Pick an object that has a hole for a shaft. The author undoubtedly made it as simple as he could and so left it as a crude bearing. Ask the students to redesign the piece for an anti-friction bearing.

Let them pick the bearing from a manufacturer's catalogue, letting them also work out the matter of fits and tolerances. Another object may be an elevating shelf which slides upon a vertical rod. This shelf can be redesigned for a gear drive, and the problem can be enlarged to include a lock to prevent unwanted sliding. It isn't necessary to give them a course in kinematics in order to solve this problem, they merely have to be informed about some simple relationships, i.e., addendum, dedendum, clearance, etc. Some of the men will want to know more; by all means -- tell them! Any ingenious instructor can find many problems which will give the students opportunities to exercise their creativity. Try to avoid having all the solutions the same by keeping the problems open-ended.

Of course this adds to the instructor's work; it will be necessary to do much more individual teaching. Furthermore, this kind of teaching calls for instructors who have a reasonable background of experience in the design field, and the instructor must love design work himself. Above all, this is important! If the teacher doesn't get a thrill from design there is little chance that his students will become enthusiastic about it. Frankly, I do not believe that the instructor who isn't convinced that design is engineering should be a graphics teacher. The situation that places young inexperienced graduates in drawing classes only to give them work during their pursuit of a graduate degree is deplorable and is exceedingly harmful to his underprivileged students.

In conclusion, let me urge that all graphics teachers become missionaries whose task it is to make the students realize that even the wonderful space vehicles of tomorrow will be loaded to the brim with hardware which they as engineers will design. Scientists? Oh, yes, we'll need a few of them also, but the guy who really solves the bulk of the juiciest problems is the engineer. I'd like to add one more item, a bit humorous perhaps. All of us have heard about the universal solvent which will dissolve anything. IF the scientists ever develop the chemical formula for this stuff, it will be the engineers who will develop the plant for making it as well as the containers for storing it.

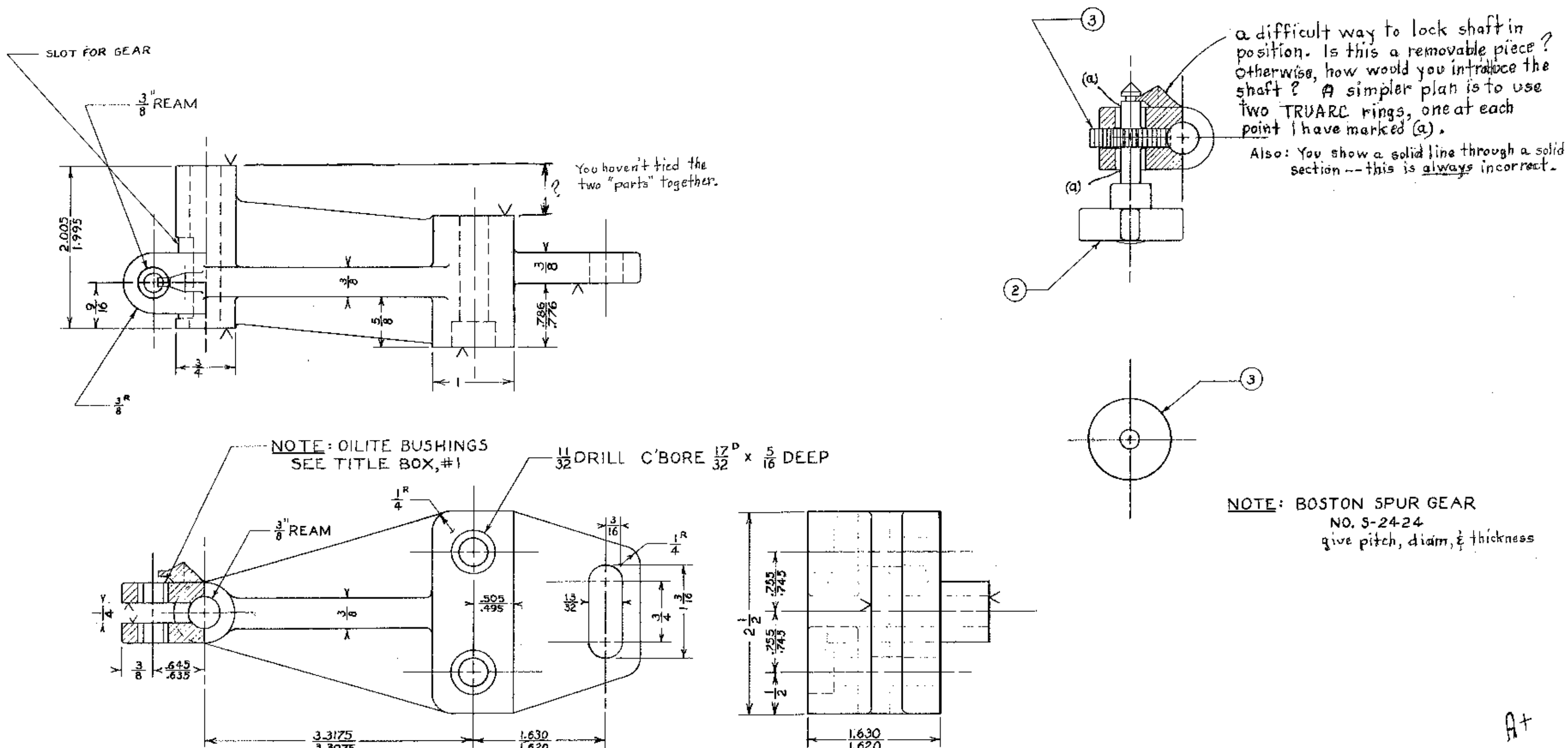
The illustration shows a drawing made by a freshman in his second month of the first semester. Obviously he had had a whoppingly good high school course, and because of this he is entered in our "advance section". The problem is taken from LUZUDDER'S' GRAPHICS FOR ENGINEERS, and the students were required to make certain alterations including the addition for an elevating mechanism. (A) In addition to this drawing, each student was asked for a freehand sketch of his own design of a semiautomatic locking device for the same bracket. Much cleverness was shown by the students in this part of the project although few were really practicable. The ordinary ratchet and pawl mechanism was ruled out because of commonness.

(A) A minimum of specification was given for this addition; substantially they were told merely to "add a geared elevating device."

EXAMPLE OF FRESHMAN'S "REDESIGN" ON OPPOSITE PAGE

NOTES

FILLETS AND ROUNDS $\frac{1}{8}$"
SLOT FOR GEAR CUT WITH
END MILL
BOST. BRONZE BEARING B46-2 2 REQ'D



A+

#3	STD. 24 PITCH GEAR	D.P.=24; #TEETH=24
#2	THUMBSCREW	DIAM. SHAFT = $\frac{1}{4}$"
#1	OILITE BUSHING	I.D.=.250" O.D.=.375
PART NO.	DESCRIPTION	SPECIFICATIONS

Beautiful work!

ELEVATOR BRACKET

THE COOPER UNION-DAY ENGINEERING

COURSE: ME II | YEAR: 1st 1961-62

DRAWN BY: R. HANNEY | CHECKED BY K.E.L.

SCALE: FULL SIZE | SEC. 2

GENERAL SCHICK RETIRES AT MILITARY ACADEMY

Brigadier General Lawrence E. Schick, Professor and Head of the Department of Earth, Space and Graphic Sciences at the United States Military Academy, West Point, N. Y., retired on 30 September 1961, after 42 years of active service.

General Schick was appointed Professor in 1946, at a time when the Academy was still operating on the war-emergency three year curriculum; and he played a key role in the comprehensive postwar modernization of plant and curriculum. In redesigning the courses presented by his department, he injected military applications highlighting the experience gained during World War II. He developed a high degree of professionalism in his instructional staff by intensifying instructor training courses and requirements for professional reading and preparation of research papers.

In the early fifties he was one of the first to appreciate the impact of technological developments in the missile and space fields and the challenge they presented to those educating young men for military careers. He pressed for more, thorough indoctrination of students in basic theory and fundamental principles and for reduced emphasis on development of vocational skills.

In the careful reevaluation of the West Point curriculum which took place during the period 1957-59, General Schick chaired the Mathematics, Science and Engineering Committee, which analyzed the subject matter of all technical and scientific courses with a view to insuring full coverage and logical development, without redundancy. Based on the results of this curriculum study, he instituted in his department the Environment Branch with courses of instruction in Physical Geography, World Geography, and Astronomy-Astronautics. This broad reorientation in the scope and nature of the instruction led to the redesignation of the Department of Military Topography and Graphics as the Department of Earth, Space and Graphic Sciences.

Throughout his service at West Point, General Schick was an influential leader in Academy activities. As chairman of the Musuem Board, he revitalized that activity and broadened its mission. He served as the unofficial Academy consulting architect, advising on the motif, design and planning of new academic buildings, cadet barracks, and many other important facilities. He also represented West Point in advising the Air Force in the overall planning for their new academy.

General Schick contributed much to West Point through his deep interest in the fine arts. He planned or contributed to the decoration of most of the major buildings on the post. He personally designed the West Point commemorative stamp and the Cadet Mess tableware, and he supervised the design of the Sesquicentennial medallion and the Thayer medal and scroll.

He did a great deal to develop the memorialization program for the Military Academy, and, while directing this program, was instrumental in establishing a number of new athletic and academic awards. He also served as advisor on the erection of Patton Memorial, the memorial to the USMA graduates who died in World War II, the Class of 1915 Memorial, the memorials in Cullum Hall, and the memorial windows in the Cadet Chapel.

Through great personal effort, General Schick raised the funds needed to restore the many immensely valuable old paintings which belong to the Academy, and he arranged for this delicate task to be performed by experts. He also organized the West Point Art Advisory Group, consisting of leading art authorities, to advise on the maintenance, restoration and disposition of newly acquired works of art. He served as Academy advisor for many paintings, including those of Generals Eisenhower, MacArthur, Arnold and Bradley.

General Schick was active in the American Society for Engineering Education, heading the arrangements for the 1949 meeting of its Middle-Atlantic Section, which was held at West Point.

He was a guest speaker before the Command and General Staff College, the Army War College, and many West Point societies and Reserve groups. In addition he served on numerous boards and standing committees, including the Academic Board, the General Committee, the Third Class Committee, the Fourth Class Committee, the Steering Group of the West Point Sesquicentennial Committee, the Memorial and Gifts Board, the Post Planning Board and the Chapel Board.

Professor Schick brought to West Point experience acquired during twenty-eight years of service in peace and war, in grades ranging from private to brigadier general.

General Schick has been held in affectionate and proud regard by many members of the Engineering Graphics Division. He has always been keenly interested in the activities of the Society and assisted us in many ways. He has always encouraged his staff to attend and participate in the Division meetings and Summer Schools. He has been eager to learn and apply whatever is useful and new in both course content and in teaching methods and has contributed significantly to both areas. He will be greatly missed by his friends in ASEE.

General Schick and his wife, the former Miss Frances M. Moore of San Diego, are returning to their home state, California. They will settle in the Monterey area. We wish them many happy days.

TENTATIVE SLATE OF CANDIDATES FOR OFFICES OF THE DIVISION, 1962-63

RULES

(a) The Nominating Committee to be appointed in June at the annual meeting shall be composed of five persons, three of whom shall be the last three past Chairmen of the Division who are present at the annual meeting (not including the retiring chairman) and two others, who are present, to be appointed by the Vice-Chairman in office with the approval of the Executive Committee. The latter two appointees shall not hold any office at the time of their appointment. The senior past Chairman of the Division shall act as Chairman.

(b) The Nominating Committee shall prepare a slate containing, for each office to be filled, two names of eligible candidates who have expressed a willingness to accept nomination and to serve if elected. The slate as prepared by the Nominating Committee shall be published in the November issue of the Journal.

(c) A properly prepared petition nominating a member for any office that bears ten (10) signatures of members of the Division and Society shall require the Nominating Committee to place the name on the ballot.

(d) The nomination period must be considered as being closed at the end of the last conference session of the mid-winter meeting. A petition for nomination received after the close of the mid-winter meeting cannot be accepted. A conference session is herein defined as a regularly scheduled meeting at which papers are presented for discussion.

(e) On March 1, and returnable before April 1, the Secretary shall mail to each member of the Division an election ballot bearing the slate prepared by the Nominating Committee.

(f) Any holder of an elective office whose term extends beyond the current year shall not be eligible for nomination to another office.

NOMINATIONS

The Nominating Committee of the Division of Engineering Graphics met at the University of Kentucky, Lexington, Kentucky, and selected the following candidates for the office indicated.

Vice-Chairman:
- Carson P. Buck, Syracuse University
- Bernard L. Wellman, Worcester Polytechnic Institute

Secretary:
- Maurice W. Almfeldt, Iowa State University
- Samuel E. Shapiro, University of Illinois (Chicago)

Director - Executive Committee:
- J. Norman Arnold, Purdue University
- Albert S. Palmerlee, University of Kansas

Circulation Manager - Journal of Engineering Graphics:
- Hugh P. Ackert, University of Notre Dame
- William B. Rogers, United States Military Academy

Division Editor - ASEE Journal:
- Noel C. McGuire, University of Texas
- Paul M. Reinhard, University of Detroit

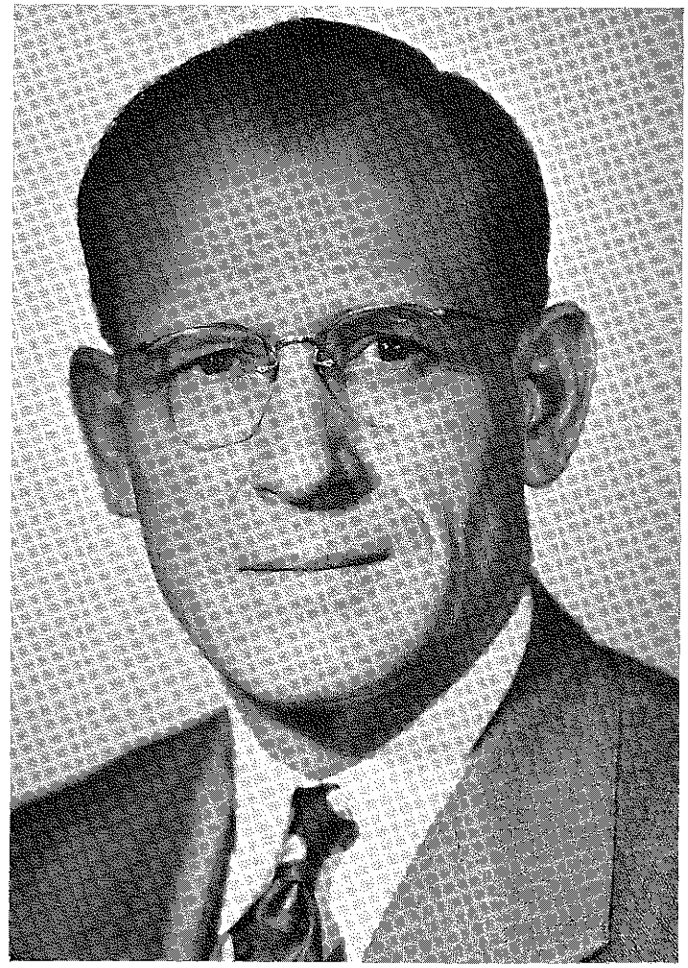
Member of Council - ASEE:
- Albert Jorgensen, University of Pennsylvania
- William E. Street, Texas A & M College

Additional candidates may be nominated by petition as outlined under paragraphs (c) and (d) of the rules given at the left. The candidate must have expressed his willingness to serve if elected. Such petitions for nominations should be presented to the chairman of the Nominating Committee by the end of the last conference of the 1962 mid-winter meeting. See rule (d).

The Nominating Committee-W. J. Luzadder, Chairman | J. S. Rising | W. E. Street | R. W. Reynolds | A. B. Wood

DISTINGUISHED SERVICE AWARD OF THE ENGINEERING GRAPHICS DIVISION OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Professor Warren J. Luzadder, Purdue University, Chairman of the Special Awards Committee, presented the Distinguished Service Award to Professor William K. Street at the Annual Dinner of the Engineering Graphics Division at the University of Kentucky, June 28, 1961



Dr. William E. Street, the recipient of the Distinguished Service Award, has had an outstanding career of service -- as a teacher, an author and a professional engineer since graduation from Texas Technological College in 1930. This distinguished teacher is recognized for his accomplishments as an engineering consultant in several fields of industry. He is a charter member of the BRAZOS Chapter of the Texas Society of Professional Engineers and was the first President of the chapter. Dr. Street has actively served the Division of Engineering Graphics for many years and is a member of several national committees that are concerned with the preparation of engineering standards.

In 1947 Dr. Street was awarded a Doctor's Degree in Engineering Education by Harding College The awarding of this degree and his notable achievements as an engineering educator and technical author testify to the fact that his primary, interest has always been teaching. After serving thirteen years as a teacher, principal and superintendent in the public school system, Dr. Street returned to his alma mater to teach engineering graphics. In 1941 he was called upon to assume the headship of the Department of Engineering Graphics at The Agricultural and Mechanical College of Texas with the rank of full professor.

Dr. Street is well known in his field as the author of the text book "Technical Descriptive Geometry" and as the co-author of several sets of problems and exercises for drawing, descriptive geometry, and lettering. In addition, he has prepared numerous articles that have appeared in national publications.

"Bill" Street is held in high esteem by the students at Texas A and M and by his colleagues. He is nationally recognized as a competent engineer and teacher and is admired for his sincere devotion to engineering and engineering education.

Dr. Street was also recipient in June, 1961 of a $1,200 award for excellence of teaching by the General Dynamcis Corporation of Fort Worth, Texas. The award was given to encourage and highlight distinguished work among engineering educators.

RESPONSE BY W. E. STREET

Mr. Chairman, Professor Luzadder, distinguished guests, ladies and fellow teachers, I am grateful to the committee and to each of you for this high honor which you have bestowed upon me. We only wish each one of you could have received the honor with us and experienced the joy, great pleasure and humbleness which we feel at this time. I say we because Clara is as thrilled over the receipt of this award as I am. She has always been very understanding and considerate when duty demanded my time. This is one of the happiest experiences of my career, and I appreciate your faith, trust and confidence in me.

I have thoroughly enjoyed my career as a teacher of Engineering Graphics since 1928. In fact my work as a graphics teacher has always seemed more like play than work. This, I am delighted to say, is in part attributed to my pleasant association with the members of the Engineering Drawing Summer School at Carnegie Tech, and to the active leadership offered by this group.

Further, I was fortunate enough to study and work under the direction of Dr. Carl L. Svensen, a great teacher of Engineering Graphics, from 1926 to 1934, when I really learned to like graphics and appreciate its unlimited value.

I am convinced that the usefulness of graphics is greater today than ever before in our history. Automation, data processing, atomic energy, aero-space technology and the like, all use graphic methods extensively and make the use of graphic methods more diversified. True, there are changes taking place in the Engineering Graphics field, but they are challenging to me and should be to all graphics teachers. It is our responsibility to see that our graphics courses challenge the minds of neophyte engineers. We should make our courses so inspirational that our students will want to be creative engineers and scientists. Let me illustrate what I have in mind.

A few weeks ago an Air Force Officer who graduated from Texas A&M College in June of 1960 walked into my office to discuss returning to school to work on his master's degree. His reason for considering giving up a career in the Air Force was that he was not doing engineering work and that he wanted to put into practice the fundamentals of engineering.

When he was on leave and working toward his bachelor degree at Texas A&M College, he took a nomography course in our department. After receiving his degree in 1960 and returning to active duty, his only engineering work was that of constructing a nomograph for use in making take-off calculations for aircraft. This nomograph replaced four graphic charts that were used to secure the same information which could now be read direct from the nomogram.

In 1942 a young orphan boy came to Texas A&M College to study engineering. Near the close of the school year, he registered for duty in the Armed Services and volunteered for service in the Air Force. At that time there were so many volunteers in the Air Force that it was necessary to wait about a year to enter training. When school was out on June 1, 1943, he went to work as a day laborer for the Houston Ship Yard. Day after day he passed a group of men trying to fit a piece of metal on the hull of a liberty ship. Finally, after several days, he stopped to inquire about the trouble. The foreman explained that they were unable to cut the metal to fit. The young man stated that he had had descriptive geometry and could work out the solution to the problem. The foreman asked if he knew that he could. He assured the foreman that he could and went on with his work. Some three hours later, the central office sent for this young man and assigned him to the job where they were having trouble. He took his drawing board and instruments out on the job and worked the problem. The metal was cut as he directed and the part fit perfectly. As a result, this person was made a trouble shooter, assigned to three ship yards several hundred miles apart, and had assigned to him an airplane and pilot to carry him from ship yard to ship yard. He saved enough money in ten months to defray the cost of his other three years of college training when he returned from the service.

Time does not permit me to relate experiences of other students, but I believe these two boys are typical of all students that are motivated to do creative thinking, and put into practice their engineering knowledge. What greater incentive can we have to meet the challenges of today than the satisfaction of a job well done.

The receipt of this award tonight and the challenges which face us tomorrow, make me feel very proud to be a part of this group.

I wish to thank all of you again for this award and for the joy which your confidence in me brings.

DIVISION OF ENGINEERING GRAPHICS
OF THE
AMERICAN SOCIETY
FOR
ENGINEERING EDUCATION

RESOLVED:

THAT, WITH THE PRESENTATION OF THIS AWARD, THE ENGINEERING GRAPHICS DIVISION OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION BY THIS TOKEN ACKNOWLEDGES THE MANY DISTINGUISHED SERVICES RENDERED BY

WILLIAM E. STREET
THROUGH THE YEARS 1929-1961

THE SOCIETY EXPRESSES ITS DEEP APPRECIATION FOR THOSE SERVICES, AND THE GREAT PERSONAL PLEASURE OF THE INDIVIDUAL MEMBERS IN HAVING HIS FRIENDSHIP.

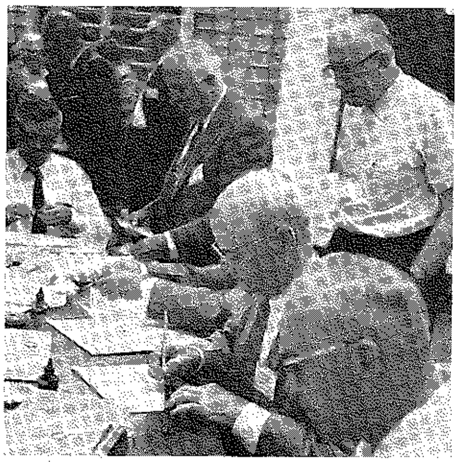
PRESENTED THIS TWENTY-EIGHTH DAY OF JUNE IN THE YEAR OF OUR LORD NINETEEN HUNDRED SIXTY-ONE.

Chairman of the Division

Secretary of the Division

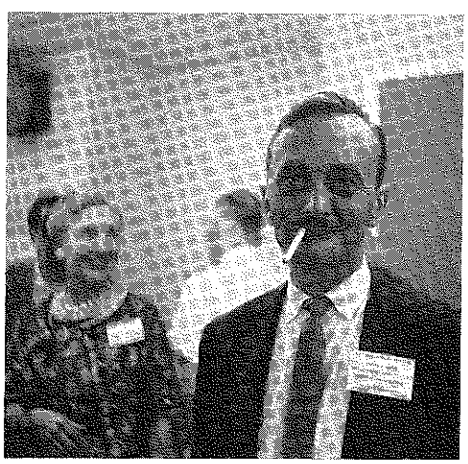
President Dickey of the University of Kentucky is host at the Annual Banquet in honor of International Engineering.

Our gracious host, Professor Clinton K. Hoffmann of the University of Kentucky busy with arrangements.

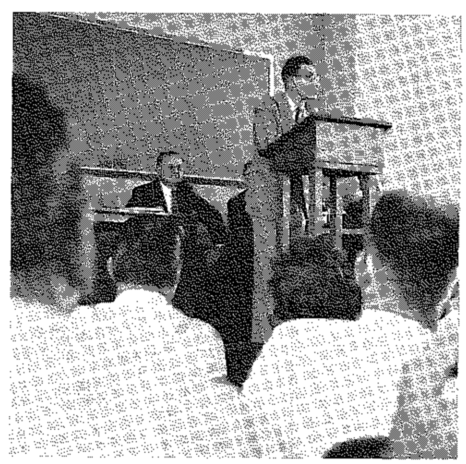


"Students" in the Engineering Graphics workshop session in visual communications. Technifax Corp. specialist B. V. Schultz and Prof. Mary Blade of Cooper Union were "teachers."

Circulation Manager of the Journal, Bob La Rue, wants you to get behind your Journal! "Write articles, get new subscribers, renew your subscriptions, interest more advertisers."

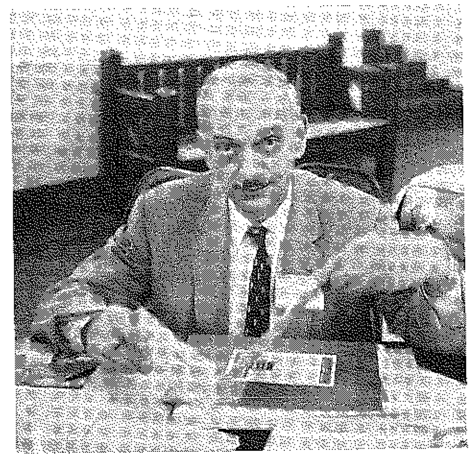


Conceptualizer Steven A. Coons of MIT after chairing a session, Engineering Graphics for Modern Engineering. Mrs. Coons in the background.



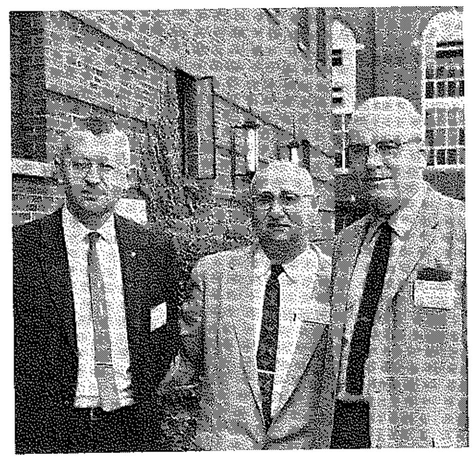
Successful author B. Leighton Wellman of Worcester Polytechnic Institute telling how to give birth to a book at the publisher's and author's session co-sponsored by 13 of the ASEE Divisions and Committees. Chairman B. R. Teare in the background. This was the hottest and best attended conference.

University of Wisconsin Winter Meeting (January, 1962) host Bob Worsencroft would like to see everyone at the mid-winter meeting.

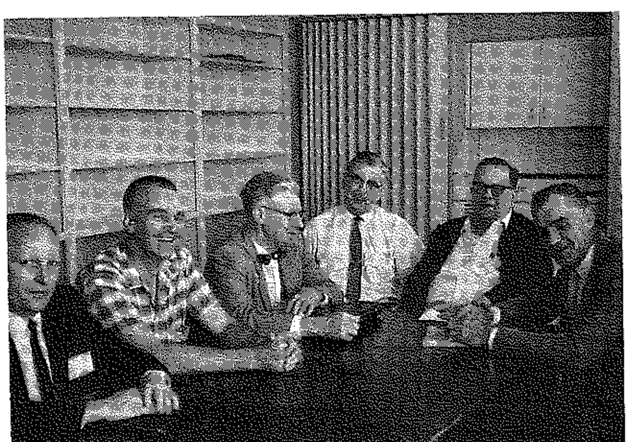


Hardworking Richard Huzarski of the University of New Mexico invites suggestions for the 1962 award in nomography.

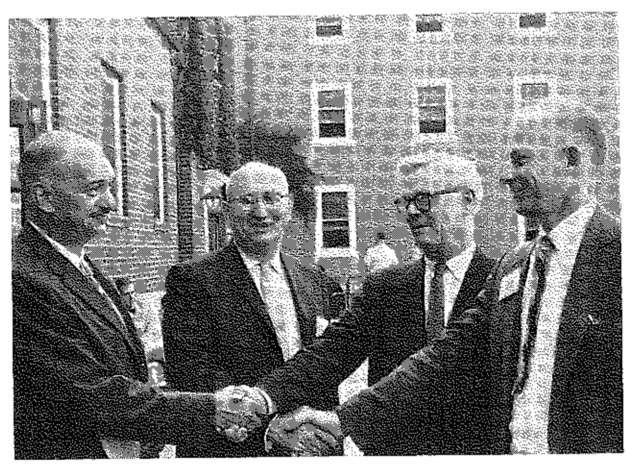
Floridian "Jack" E. W. Jacunski and Duke Ralph E. Lewis.



1960-61 Chairman Irwin Wladaver of New York University who arranged the excellent program of the Division at the Kentucky Convention. Flanked by E. Weidhaas of Pennsylvania State University and Matthew McNeary of the University of Maine.



"Futures" committeemen. Paul Reinhard, University of Detroit, Bob Hammond (now Colonel) of West Point, Earl Black of General Motors Institute, Carson Buck of Syracuse University, Ralph Lewis of Duke, and E. W. Jacunski of the University of Florida.



Congratulating Nomography Award Winner M. E. Arthur is R. Huzarski. Congratulating Irwin Wladaver is Ellis Blade.

NOMOGRAPHY AWARD FOR 1960-61

Professor Richard G. Huzarski, of the University of New Mexico, Chairman of the Nomography Committee, announced the committee decision to divide the Nomography prize between two recipients. At the Engineering Graphics Division Dinner at the annual ASEE convention held at the University of Kentucky in June, 1961, the International Harvester Corporation Award in Nomography was presented to Mr. Harvey Meeusen of the General Motors Co. for his article, "The Application of Nomograms to the Solution of an Engineering Problem," published in the General Motors Magazine; and to Mr. M. E. Arthur of the International Business Machines Co. for his article, "A Nomogram for Voltage Dividers," published in Electrical Design News. For further news of Mr. Arthur see his Nomogram for Ellipses in this issue of the Journal.

GRAPHICS SEMINAR AT PRINCETON

Graphics faculty members from Rutgers University, Manhattan College, Pennsylvania State University and The Cooper Union School of Engineering joined engineering faculty at Princeton in a graphics seminar on Monday, November 13. Speaker was Professor Forrest Woodworth of the University of Detroit. He spoke on "The Graphical Solution of First Order Differential Equations." His paper was followed by a lively question and answer session and a dinner and informal get-together. Professor Steve Slaby of the Department of Graphics and Engineering Drawing at Princeton made the arrangements.

Professor Slaby is to be congratulated in this first informal Middle-Atlantic Metropolitan Meeting of graphics teachers. Although there are over a dozen engineering schools within 50 miles of New York City teaching about 10% of the country's engineering students, there have been no meetings or opportunities to talk shop, discuss new advances in graphic science, except ASEE meetings and it has been many years since Middle-Atlantic section meetings scheduled sessions devoted to graphics. Though 9 colleges are all within 15 miles of each other, for all purposes of interchange, they might as well be in Timbutu! It is encouraging to see a start in the type of professional meeting which could be so fruitful in ideas, mutual problem solving and friendships. A second Princeton seminar is being planned by Professor Slaby which will convene in January or February, 1962, led by Professor Steven Coons of Massachusetts Institute of Technology. Interested persons should write to Professor Slaby for details.

Other news from Princeton: Frank Heacock, Emeritus Professor, is working on a book to contain summary reviews of 3000 articles on graphic solutions of engineering and science problems. Professor A. L. Bigelow's book on "The Acoustically Balanced Carillon," published by the Dept. of Graphics, School of Engineering at Princeton, received a prominent review in the New York Times this fall.

SUMMER SCHOOL
U. S. AIRFORCE ACADEMY, JUNE 14-16, 1962
THEME: ENGINEERING GRAPHICS FOR THE FUTURE

Begin planning now to attend the Summer School of the Division of Engineering Graphics and bring the family.

The Summer School will open on Thursday Evening, June 14, with a general meeting at which The Divisional Committee on Future Development, Dean Carson Buck, Chairman, will outline the "Future of Engineering Graphics." The Committee on Aims, Scope and Content of Engineering Graphics, Professor George Stegman, Chairman, will follow up with the objectives and goals that our courses should have to bring to fulfillment the outline for the future.

A series of workshops will be held on Friday and Saturday. These will be small groups, about thirty in most cases, on such topics as Elementary Nomography, Basic Graphical Mathematics, Closed Circuit Television, Administration of Graphics Courses, (for course leaders and department heads), Advanced Nomography, Advanced Graphical Mathematics, Teaching Machines in Engineering Graphics, The Computer and Engineering Graphics, Advanced Problems in Descriptive Geometry, Tests and Test Analysis and Design in Engineering Graphics Courses.

Each workshop will be of three hours duration. It will involve the active participation of the audience who will solve problems, program computers, plan a television lecture, start writing the syllabus for a new course, or begin programming their courses on a teaching machine.

Friday Evening there will be a "This is how I teach it" session. Everyone of us has developed some teaching device, trick or gimmick that has been successful in getting across a particular topic. This meeting is an opportunity to share your idea with others and get some new ideas yourself. How many remember the "Newton Point Trap" or Harold Howe's dramatic presentation of the intersection of two cylinders, freehand, on the blackboard, without prior preparation, at the Summer School at Michigan State? Everyone come prepared to demonstrate your successful idea at the "How I teach it" meeting.

The Summer School will close Saturday evening with a dinner which will include the ladies.

Come one, come all and help plan and make the future for Engineering Graphics.

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New Engineering Books....

PROBLEMS IN APPLIED DESCRIPTIVE GEOMETRY

By MATTHEW McNEARY, University of Maine. 144 pages, $3.95.

Helps the student apply his knowledge to actual situations by following each of the twenty-one teaching units with applied problems. Given conditions are laid out in orthographic form to save time usually spent in setting up problems. In addition to full coverage of point, live, and plane relationships, topics include the intersection and development of surfaces, vector geometry, and applications to geology. To challenge the superior student, a special group of difficult problems is appended.

CREATIVE PROBLEMS IN ENGINEERING GRAPHICS

By ERNEST R. WEIDHASS, The Pennsylvania State University. 118 pages, $4.95.

Features the creative design element (starting with simple design decisions and working up to truly creative design), which serves to place graphics in proper focus—as an aid in engineering design and as a means of communicating that design to others. It encourages the latent creative talents of our future engineering designers, as creative design decisions are required throughout. The student must repeatedly go through the sequence: idea, design sketch, design drawing. New topics introduced in this text make the book equally suitable for either an engineering "graphics" or "drawing" course.

GRAPHICS

By JOHN T. RULE, Massachusetts Institute of Technology, and STEVEN A. COONS, Massachusetts Institute of Technology. 496 pages, $8.95.

Covers all phases of graphics, and sets forth its power in three major activities: conceptualization, in which new ideas are generated to satisfy human needs; analysis, in which graphical methods either replace mathematical computation or augment and facilitate it; and communication, in which the traditional Engineering Drawing is shown to be a language based on logical syntactical rules. Included, are chapters on graphical calculus, together with new material on solution of differential equations; information flow diagrams, projective geometry, and periodic functions. The chapter on Freehand Sketching encourages frequent use of sketches not only in representation of objects, but also as a tool of the thought process.

Problem Books Available

ENGINEERING DRAWING PROBLEMS

By FRANK ZOZZORA, The University of Delaware. Second Edition. 192 pages, $4.50.

PROBLEMS IN GEOGRAPHICAL ANALYSIS

By PERCY H. HILL, Tufts University. 162 pages, $5.50.

PROBLEMS IN ENGINEERING DRAWING, Series V

By A. S. LEVENS, University of California, and A. E. EDSTROM, City College of San Francisco. 224 pages, $5.50.

PROBLEM LAYOUTS FOR TECHNICAL DESCRIPTIVE GEOMETRY

By B. LEIGHTON WELLMAN, Worcester Polytechnic Institute. Second Edition. 112 pages, $3.95.

ALTERNATE PROBLEM LAYOUTS FOR TECHNICAL DESCRIPTIVE GEOMETRY

By B. LEIGHTON WELLMAN, Worcester Polytechnic Institute. Second Edition. 110 sheets, $4.50.

ENGINEERING DRAWING PROBLEMS, Series 1

By HIRAM E. GRANT, Washington University, St. Louis, Missouri. 60 sheets, $5.00.

CREATIVE PROBLEMS FOR BASIC ENGINEERING DRAWING

By MATTHEW McNEARY, University of Maine; ELIZABETH A. KELSO, University of Maine; and ERNEST R. WEIDHAAS, Pennsylvania State University. 52 pages, $4.50.

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Best Sellers in Engineering Graphics

TECHNICAL DESCRIPTIVE GEOMETRY

By B. LEIGHTON WELLMAN, Worcester Polytechnic Institute. Second Edition. 640 pages, $6.50.

Written in simple language, arranged in an easy-to-read format, and generously illustrated, this book provides a comprehensive and modern treatment of the theory and practical applications of descriptive geometry. The popular auxiliary view method is reduced to its simplest elements, and the entire subject is developed realistically from a natural, logical viewpoint. There are no imaginary planes and projections. Consistent with industrial practice, attention is concentrated on the object itself, and the direction of sight for the various views is emphasized.

ENGINEERING DRAWING

By FRANK ZOZZORA, The University of Delaware. Second Edition. 391 pages, $7.25.

A concise, profusely illustrated text emphasizing step-by-step procedures in engineering drawing. Both the text and the problems have been prepared to meet the needs of students at any level from trade school to university. This text will enable the student to cover the fundamentals of engineering drawing, descriptive geometry, and graphical analysis, in the short time allotted, and to acquire those fundamentals basic to any drawing he may do in industry.

GEOMETRY OF ENGINEERING DRAWING
Descriptive Geometry by the Direct Method

By GEORGE J. HOOD, Emeritus, University of Kansas, and ALBERT S. PALMERLEE, University of Kansas. Fourth Edition. 347 pages, $5.75. Problem Sheets, Fourth Edition, $3.75.

This pioneer text in introducing the direct method of teaching descriptive geometry adopts the procedures, vocabulary, and point of view of the engineer as he visualizes and designs structures. New material and many new illustrations appear in this thoroughly revised edition along with 960 entirely new problems.

A MANUAL OF ENGINEERING DRAWING FOR STUDENTS AND DRAFTSMEN, New Ninth Edition

By THOMAS E. FRENCH; and CHARLES J. VIERCK, University of Florida. 744 pages, $8.50.

This all-new ninth edition is an up-to-the-minute revision of the foremost text in its field. It conforms to current standards set for engineering drawing and has been expanded for better explanation and coverage. Designed for the longer first and second year courses, it contains the most advanced material on graphic communication available.

FUNDAMENTALS OF ENGINEERING DRAWING

By THOMAS E. FRENCH and CHARLES J. VIERCK, University of Florida. 552 pages, $7.50.

This text is a shortened version of the authors' A MANUAL OF ENGINEERING DRAWING FOR STUDENTS AND DRAFTSMEN, 9th Edition, and GRAPHIC SCIENCE. It is geared to the short first-year course and intended as an introduction to the essentials of graphics which a draftsman or engineer in practically any field of engineering must know.

GRAPHIC SCIENCE: Engineering Drawing, Descriptive Geometry, Graphic Solutions.

By THOMAS E. FRENCH; and CHARLES J. VIERCK. 760 pages $8.50.

Combines in one volume the three core subjects in drawing: engineering drawing, descriptive geometry, and graphics. The focus throughout is on drawing as a tool of the engineer. Emphasis is placed on the "science" of graphics, rather than the "art" of graphics.

APPLIED DESCRIPTIVE GEOMETRY

By FRANK M. WARNER, University of Washington; and MATTHEW McNEARY, University of Maine. Fifth Edition. 243 pages, $5.50.

The present edition retains all the features that have made the book so popular in the past—conciseness, readability, and challenging applied problems. Nomenclature is kept simple. New additions include sections on visibility, shortest level line and shortest line of given slope between two lines, contour map problems, geology applications, coplanèr vectors, and the fairing of complex double-curved surfaces.

PRACTICAL DESCRIPTIVE GEOMETRY

By HIRAM E. GRANT, Washington University. 253 pages, Regular Edition (Without Problems), $5.25. 403 pages, Alternate Edition, $5.95.

Correlates and integrates theory and practice, instead of considering each as a separate entity. Here are new methods for solving many fundamentals. All illustrations are thoroughly explained and practical applications of theory are stressed. The alternate edition includes 925 problems—made up of 405 theoretical problems and 520 practical problems. Most problems were compiled from the actual files of approximately 300 United States and Canadian industrial firms.

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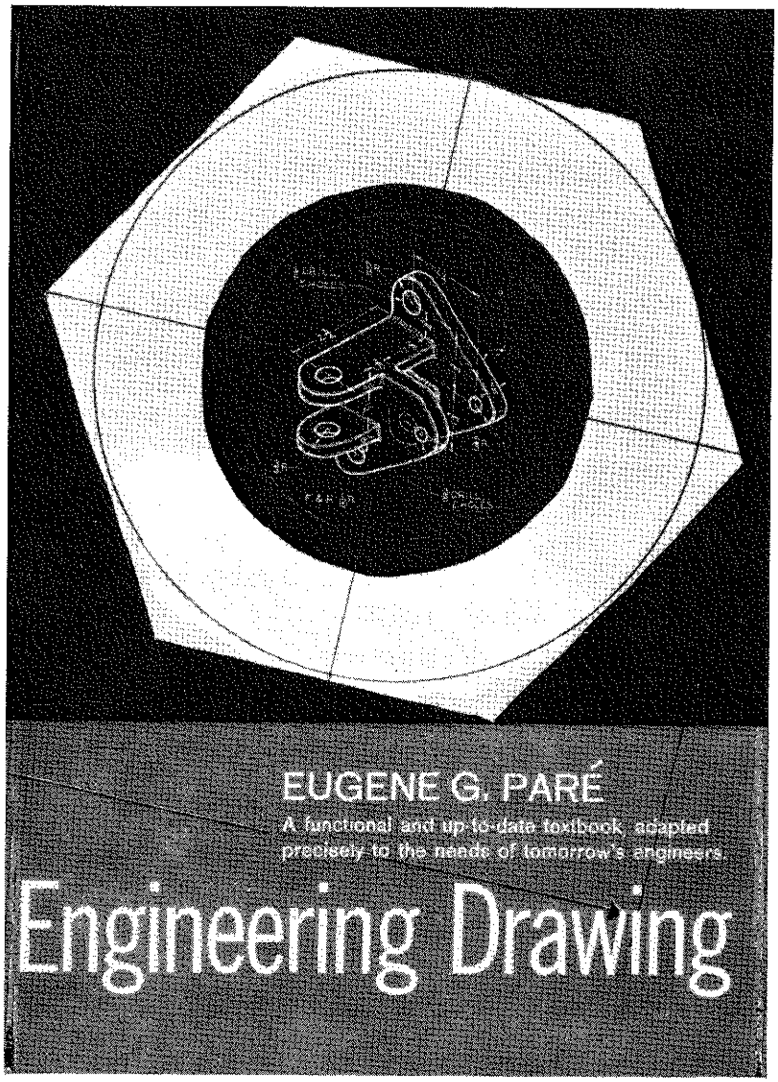

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1961, $4.50 (tent.) paper

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Primarily for technical institute students. 64 sheets printed one side, 2 sheets tracing paper.
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