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EDITORIAL

This issue of THE PENTAGON marks the return to the prewar practice of publishing two numbers each year, one in the fall and one in the spring.

The war disrupted the activities of most of the chapters of Kappa Mu Epsilon. Some chapters found it necessary to become inactive because of the lack of students; other chapters were forced to curtail their programs because of the accelerated schedules. As a consequence, THE PENTAGON has been unable to carry out its plan of becoming a journal devoted to articles on mathematics written for and by students. We feel that there is a real need for such a journal.

The response to our appeals for student articles has been disappointing, but understandable. But now that the war is over, the students will soon return to the colleges in larger numbers than ever before. The chapters will find it possible to resume normal functions and to plan bigger and better programs. These programs should be the source of many fine papers for THE PENTAGON.

We urge that each chapter consider its number one project to submit at least one student paper to THE PENTAGON each year.

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LESSER KNOWN APPLICATIONS OF MATHEMATICS

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A great many people have the idea that mathematics is a physical science, an idea probably derived from the fact that many applications of higher mathematics have been in the field of the physical sciences. However, there is nothing that has a richer profusion of applications and nothing that covers the whole domain of human knowledge as does mathematics. The applications of mathematics to the fields of physics, astronomy, chemistry, etc., are well known to most of us. In this paper we consider briefly a few of the lesser known applications of mathematics.

In the whole group of biological sciences, there has been very extensive use of mathematics in a great many connections. For one thing, in genetics, maps of genes and chromosomes have been traced out through experiments, not on the germ cells in which these chromosomes are seen, but on the organisms growing out of the cells. These experiments involve breeding fruit flies and classifying the offspring, watching the occurrence of frequencies, and deducing from these frequencies the position of certain minute genes on the chromosomes, genes so small you can't see them in the microscope. All this has called for the development of a very great deal of mathematical research.

Also, we find many varieties of measuring apparatus, tables, and graphical representations in the field of biology. For example, there is an apparatus which indicates the growth of a plant in a flowerpot. Apparatus for the determination of the amount of absorbed carbon dioxide, as well as for the determination of the amount of acid material, is found in every biological laboratory.

When a branch of a plant spreads out in smaller branches, it loses an energy E. If we denote the energy of a new smaller branch by e and the angle between the two branches by α, then $E = e \cos \alpha$. The arrangement of the leaves on a plant is described by means of a fraction belonging to the sequence 1/2, 1/3, 2/5, 3/8, 5/13, 8/21, etc. These fractions are intimately connected with Fibonacci's series. If one wishes to study thoroughly the inner and outer structures of biological bodies, he must be proficient in space representation. In this respect a knowledge of geometry and space perception is of great help to biological studies.

Very careful investigations have shown that the bee is able to build honeycomb cells with a minimum amount of material. The cells are six-sided prisms with a superimposed pyramid consisting of three rhomboidal plates. Exact mathematical calculations by means of the differential and integral calculus have substantiated the fact that the bee encloses a maximum of space with the minimum amount of wax.

Before passing on to another field, perhaps it might be interesting to note here that one of the most astonishing formulas is that derived by Dr. Carrel to determine whether a wound is healing at the correct rate. He measures the area of the open wound twice, six days apart, substitutes the measurements in a formula, and from the result can tell whether or not the wound is healing according to schedule. If not, he may decide to probe in the wound for foreign matter.

It is through the theory of statistics that a great deal of mathematics is brought to bear upon various fields such as economics, sociology, anthropology, education, biology, etc. The theory of statistics, a very extensive branch of mathematics, is based on the theory of probability. It serves to help one interpret the evidence that accumulates from observations, and also to guide one in the accumulation of observations in order that the evidence may be obtained.

In the social sciences we find a considerable variety of applications of statistical methods as well as of other types of mathematics not involving statistics. In economics, mathematics is usually thought of as a matter of statistics. However, even here, there are very important applications of mathematics that are not at all of a statistical character such as applications of advanced calculus, differential and integral equations, and functional equations. Higher mathematics is used to solve problems of maxima and minima, as in the simple process of determining formally the price that the traffic will bear in order to make a maximum profit. The problems of economic theory to which mathematical analysis of this formal kind applies are those of supply and demand, the determination of prices, and the theoretical effect of taxes or tariffs on prices.

In history, which one considers as non-mathematical a subject as could be found, various questions about chronology are encountered where mathematics has made its influence felt. According to accepted chronology, there were in the early days seven Tarquin kings of Rome who reigned for a total of 350 years. Karl Pearson examined the question whether 50 years per king wasn't a good deal for seven of them in a row. He went at the problem in two different ways. One way was with the aid of an actuary and a modern actuarial table; he came out with the result that 50 years per king was perfectly incredible, even without taking account of the fact that few Roman kings died in bed and that their lives were cut short much more drastically than the lives of modern men. From another standpoint, Pearson examined the lengths of the reigns whose dates are accurately known, including such long reigns as Louis XIV (who reigned 72 years) and Queen Victoria, and also a great many short reigns. On the basis of this frequency distribution, Pearson again arrived at the conclusion that it was incredible that seven kings in a row should reign on an average of 50 years each. The revision of chronology has thus been made necessary by the theory of probability.

Many artists use a mathematical approach to their paintings. They believe that a picture must be carefully organized and executed. The artist cannot start at the top of the canvas and work down as far as he likes. Nor does he wait until he has received that creative inspiration which drives him to dash up to his studio and brush out a masterpiece.

Research in the history of art reveals that mathematics played an important part in the creations of the Assyrians, the Egyptians, the Greeks, and the Orientals. In Assyrian art and architecture, the decorations were harmoniously proportional to the surfaces and areas of the buildings. The Egyptians applied the use of mathematics to their art and architecture by establishing definite rules of proportion and measurement. Through the use of rope-stretching in re-surveying flooded lands, they developed concepts of geometry and applied these principles to their art. The classical masterpieces of the ancient Greeks have been studied for 500 years in an effort to find the mathematical formulae basic to their flawless structures. Artists are convinced of the need for a thorough understanding of mathematics that may apply to art.

With the fall of the Roman civilization by 476 A.D., practically all paintings were lost to the world and only the masterpieces of architecture and sculpture remained as an inspiration to artists. With the destruction of paintings by the barbarians, the technical principles involved were also lost. Prior to the Renaissance of the 14th century, the only paintings in existence were the crude, flat, stereotyped, monotonously symmetrical works of the early Christian painters.

The outstanding contributions of mathematics to art during the period of the Renaissance were the laws of linear perspective, geometric construction, human proportions, atmospheric perspective, and light and shade. A study of the paintings of four representative artists of the Renaissance will summarize the technical development of that period.

Giotto marks the beginning of the effort to recover the use of mathematics in art. He attempted to represent man and nature in three dimensions. This can only be done accurately with a knowledge of linear perspective. While he did not develop adequate rules for perspective, his pioneering endeavors created a need for mathematical principles. However, he succeeded in breaking the tradition of the flat, symmetrical picture. For example, in his *Last Supper* we see traces of the traditional emphasis on symmetry through repetition of certain disciples. Yet he broke all traditions by placing Christ at one side of the picture. This off-balance arrangement developed the need for a new type of composition and the use of mathematics in directing centers of interest. Giotto was not highly successful in leading the spectator's eye to Christ even though he gave Him a different type of halo and turned several of the disciples toward Him. Analysis of this picture fails to reveal the use of vanishing points or eye-lines. Consequently, Giotto's picture is not over two yards in depth. His efforts to portray three dimensions brought many mathematical problems which he was unable to solve.

Solutions for these problems of perspective were discovered by the great research artist Uccello. Although he had many opportunities to become a popular and wealthy painter, he insisted on spending his time and energy in the technical analysis of linear perspective. His success in locating the vanishing points of a 72-faced polyhedron was only one of the very complex problems he undertook. The drawings and paintings of Uccello became mathematical textbooks for the painters of the Renaissance. But it remained for Francesca to record and develop Uccello's ideas. Francesca's textbook became a practical handbook for artists in training. One of his pupils, Pacioli, contributed two texts on the use of mathematics in art.

The culmination of artistic progress in the Renaissance can be found in the work of the genius Leonardo da Vinci. He combined a thorough understanding of mathematics and science with that inspiration that creates masterpieces.

Perhaps his greatest contributions to art come from his research on the human figure. By actual measurement of human proportions and the dissection of cadavers, he arrived at a group of laws governing the construction of the body. His notebooks contain a remarkable record of the mathematical problems faced by artists.

An analysis of da Vinci's *Last Supper* is proof of the value of mathematics as applied to linear perspective. All the lines in this picture converge to Christ's head, the center of interest. In order to study the accuracy of linear perspective in this painting, projections of the ground plan and elevation were made from a print. These projections furnish undeniable evidence that the painting was developed with a full knowledge of mathematical perspective and that the principles were applied with exactness. The perfection of Leonardo's work is especially apparent when it is compared with the same subject as painted by Giotto. In Giotto's *Last Supper* it is impossible to locate the vanishing points and eye-lines, while in da Vinci's they are obvious.

Thus we see that mathematics is applied to many unusual problems in unusual ways. It has not been my purpose to exhaust the subject, but rather to point out some of the many problems which require a background of mathematics for their solution.

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HOW CAN WE HELP HIGH-SCHOOL COUNSELORS UNDERSTAND THE VALUES OF MATHEMATICS?

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Not long ago, a young man applied for admission to Central Michigan College to start work on a pre-engineering course. In checking his credits it was found that he had taken no geometry in high school. Upon questioning him, it was discovered that he had planned all through high school to be an engineer but that no one, apparently, had ever told him that geometry was a necessary subject for such a course.

Very recently, I interviewed a young lady who had been denied admission to another college, in which she wished to enroll for a course in hotel administration, because she had not taken algebra in high school. Again the story was that no one in her school had ever informed her that a mathematical background was necessary for such a course.

If the two foregoing illustrations were only isolated incidents, we should not, perhaps, concern ourselves too seriously. It is a fact, however, that such situations are occurring with increasing frequency as high-school graduation requirements and general college entrance requirements are being relaxed or "liberalized".

The student who finds himself in the situation illustrated is frequently severely penalized through no fault of his own. He may have to delay college entrance for as much as a year in order to make up the deficiency. At best he may be given conditional admission and carry a reduced college program while making up the high-school work.

Why has such a situation arisen? In the opinion of the writer, the following factors are contributory:

1. *The relaxed graduation and entrance requirements.* Ten years ago, most high schools required at least one year of algebra and geometry for graduation, and most colleges required the same subjects for entrance. College curricula were set up on the assumption that students would have this elementary equipment in mathematics.

During the last ten years most high schools have eliminated the mathematics requirement for graduation, and many colleges have eliminated the requirement for general admission. These two facts have received wide publicity and, as a consequence, an increasing number of students are graduated from high school and apply for admission to college without this fundamental training. An important qualification, however, which has not received equal publicity, is that most colleges, while giving general admission to such students, will not admit them to any curricula for which a background of elementary mathematics is a necessary prerequisite. The following quotation from the catalogue of the University of Wisconsin is an illustration:

> Mathematical preparation is essential for successful work in many fields of study in which the University gives instruction. Students are, therefore, strongly advised to enter with mathematical preparation. It is requisite for advanced work in most of the fields and is, therefore, required of all students who choose to major or specialize in such a field. The University does not give residence courses in elementary mathematics; hence, a deficiency in high-school mathematics can be removed only by taking entrance examinations, or by returning to high school, or by taking correspondence courses from the Extension Division.
>
> With Mathematical Preparation an Admitted Student May Enroll In
>
> (a) The College of Letters and Science. He may register in any course or field of study to which freshmen are eligible, and may exercise full freedom of choice among the college majors and fields of specialization.
>
> (b) The College of Engineering. For full admission to this college 1½ units of algebra and 1 unit of plane geometry are required. *Students who present the minimum requirement for mathematical preparation will be required to complete one semester of college algebra without credit* before beginning the regular courses in engineering mathematics.
>
> (c) The College of Agriculture. A student wishing to specialize in technical Agricultural Engineering should present the same units as are required in the College of Engineering.
>
> (d) The School of Education.

Without Mathematical Preparation An Admitted Student May Enroll In

(a) The College of Letters and Science, and he may take some work in most of the departments; and by carefully exercising his options he may take the courses in journalism or music or he may major in Hispanic studies, art history and criticism, the classics, comparative literature, English, foreign languages, geography, history, philosophy, or speech. *However, no classes in astronomy, mathematics or physics will be open to him. He may not enroll in the course in chemistry, medical technology, nursing, pharmacy nor may he major or specialize in American institutions, bacteriology, botany, chemistry, commerce, economics, geology, humanities, international relations, mathematics, physics, pre-medicine, political science, psychology, sociology, or zoology.*

(b) The College of Agriculture, including Home Economics, except technical Agricultural Engineering. However, the deficiency in mathematical preparation must be made up without college credit before he enters the junior year.

(c) The School of Education. Freshmen and sophomores in the College of Letters and Science who expect to transfer to the School of Education and elect a teaching major in an academic field, shall comply with the requirements of the College of Letters and Science. No student may graduate from the School of Education with a major or minor in any of the fields which require mathematical preparation (see above) until the deficiency has been removed. By carefully exercising his options a student may complete the courses in Applied Art, Art Education, or Physical Education for Men. However, the completion of the course in Physical Education for Women requires mathematical preparation.

This statement is fairly typical of the requirements in most colleges and universities, and some way must be found to publicize this situation among our high-school students and teachers.

2. *The de-emphasis on mathematics.* Since many students find the discipline of mathematics difficult and irksome, many high-school administrators and counselors have taken the "easy way" and have not urged their students to study mathematics. The tendency in some schools to adopt so-called "progressive" curricula and methods has fostered this policy.

It is lamentable that certain extremists in the progressive education group have obtained wide hearing and their ideas have been blindly followed by a number of secondary administrators. Among the "principles" advanced by some of these people are

(1) The student should study only those things which are pleasant and interesting;

(2) Nothing should be taught until the student feels a need for the subject or develops an interest in it.

(Somehow explanations are lacking as to how the student is to acquire an interest in or feel a need for a subject with which he has had no contact.)

As a result of these and similar ideas there has been apparently a considerable "softening" of academic standards as regards mathematics. Drill has been relegated to the educational junk-heap as outmoded and unnecessary. Some schools have gone so far as to discontinue teaching algebra and geometry in the high school. This is not too surprising when some state educational officials and even prominent men in our institutions of higher learning make wild statements to the effect that the average high-school student does not need to know anything about mathematics.

The disastrous results of this trend were brought out with startling clarity when the United States was plunged into war. The widely circulated Nimitz letter and other pronouncements by civilian educators and military leaders spotlighted the woefully weak mathematical background of our present day high-school graduates. This deficiency in mathematical training has resulted in untold delay in getting our army and navy ready to fight. The armed forces have been forced to spend vital time in giving trainees the mathematical training they should have had in elementary school, high school, and college. To illustrate, in the V-5 Naval aviation-cadet training program, it was found necessary to devote one-sixth of the entire ground-school time to a "refresher" course in arithmetic, algebra, and geometry. If these boys had been properly trained in mathematics they could have started immediately on their study of navigation, physics, and meteorology and their whole flying course speeded up as a consequence.

People who damage war equipment or who slow down war work are known as saboteurs. I wonder if we are not justified in pinning that label on the individuals who are responsible for the deplorable mathematical education of our present generation, since they have just as surely slowed down the production of trained personnel for our armed forces.

Many of these same individuals now grudgingly admit that a knowledge of mathematics is necessary in time of war. They are quick to add, however, that now the emergency is past we can forget all the disagreeable necessities of war and resume the pursuit of "progressive principles" of education.

They do not, apparently, recognize the complex scientific structure of our civilization. If this civilization is to continue we must increase, not decrease, the emphasis on sound mathematical training. We must restore an appreciation of the values of manipulative processes, and re-establish in the minds of the public and of school officials the fact that these processes can only be acquired by drill and that drill is hard work and not play.

During the war mathematics has regained somewhat its position of importance in the secondary curriculum, but now that the war is over there are signs that we may rapidly relapse into the prewar trend unless definite steps are taken to point out to people in control of high-school curricula that the values of mathematics are as valid in peace as in war, even though they may not be so dramatic.

3. *The lack of information of high-school counselors.* The ranks of secondary counselors are filled largely with people who have done their graduate work in the field of guidance and who, in many cases, have not had much background in mathematics and sciences. Even those who have had considerable undergraduate or graduate work in mathematics may not be fully aware of the large number of fields in which a background of elementary mathematics is necessary for profitable study.

Some counselors are definitely antagonistic to mathematics and severely censure the colleges when students are not allowed to enter certain fields of study because of high-school deficiency in mathematics. This may be due to a desire to "cover up" their own deficiency in information regarding these fields of study and their consequent failure to give the student adequate guidance.

The United States Navy has published an excellent poster entitled "Navy Educational Program" listing the mathematics and science background for twenty-six different types of work in the Navy and indicating the corresponding jobs in civilian life. If this poster could be placed in the hands of every high-school counselor, and its implications followed in counseling, much of our difficulty would be solved.

There are, of course, many other fields of work not covered by the Navy poster which should receive similar treatment. How many high-school counselors are aware of the large number of fields, such as those mentioned in the previous quotation from the University of Wisconsin catalogue, that require a background of mathematics for admission to study? Is such information readily available to high-school students? If not, what can be done about it?

An important phase of the problem is the education of our prospective teachers of mathematics. Until comparatively recently, most of our college seniors graduating in the field of mathematics had a rather hazy idea of how and where mathematics is used in the world's work. Their college course consisted largely of a few courses in algebra, trigonometry, analytics, calculus, and perhaps theory of equations, differential equations, or history of mathematics, along with a course in methods of teaching mathematics. While references to applications are normally made in most of these courses, yet many important applications are not usually mentioned, due, perhaps to lack of time, and as a result many teachers go into their first year of teaching with little more than a reasonably good foundation in the techniques of manipulation. Such courses as those organized by Schuster[1] and the writer[2] are an attempt to get at this particular phase of the problem. Much remains to be done, however, in this area to make sure that our teachers of secondary mathematics are aware of the wide range of uses of mathematics.

Even if all our teachers of secondary mathematics were fully informed about all the applications of mathematics and were themselves completely aware of the values of mathematics our problem still would be far from solved. Some way must be found to inform and convince high-school administrators, counselors, and other teachers of these values, since they have in general more influence on the course selection of the high-school student than do the teachers of mathematics.

It is the opinion of the writer that mathematical organizations and individuals interested in sound mathematical training should assume the responsibility of conducting a campaign to disseminate such information and to educate school administrators and the general public to the values and uses of mathematics. This might be done through conferences of high-school counselors (though mathematicians are rarely invited to address such groups), or through a campaign of direct circulation of literature giving the essential information.

Michigan Beta Chapter of Kappa Mu Epsilon has been considering the compilation and publication of a pamphlet under the title "Why Study Mathematics in High School?" Our purpose would be to inform the high-school students, teachers, and counselors of our immediate area as to the fields of study requiring a mathematical background. It is our feeling that this might at least tend to remove the validity of the statement, "No one ever told me I needed mathematics for this field of study."

To secure wide coverage of such a project would entail considerable expense. If the project is to be of maximum

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1 C. H. Schuster and F. L. Bedford, *Field Work in Mathematics*. New York, American Book Company, 1935.

2 C. C. Richtmeyer, "A Course in Applied Mathematics for Teachers of Secondary Mathematics", *The Mathematics Teacher*, Vol. 31, pp. 51-62 (Feb., 1938).

value it should be undertaken on a nation-wide basis. Zant[1] has recently made a similar suggestion. I am wondering whether it would not be worthwhile for the national organization of Kappa Mu Epsilon to consider the feasibility of conducting such a program of information throughout the entire country.

The writer would be very glad to have reactions of members of other chapters of Kappa Mu Epsilon and to receive any suggestions which they may care to advance.

1 J. H. Zant, "The Next Stop in Planning for Post-War Mathematics," *The Mathematics Teacher*, Vol. 38, pp. 276-277, (Oct., 1945).

Throughout his researches Laplace seems to have regarded analysis merely as a tool for attacking physical problems, although his ability to handle analysis was phenomenal. He took but little time to explain how certain results were obtained as long as the results were true. Dr. Bowditch who brought out an English translation of the *Mecanique* Celeste was accustomed to remark, "Whenever I meet in Laplace with the words 'Thus it plainly appears', I am sure that hours and perhaps days of hard study will alone enable me to discover how it plainly appears."

—A. W. RICHESON.

THE MATHEMATICAL SAGA OF LINNIE R. E. QUASHUN[1]

Once upon a time, there lived in the far —(1)— of our country which —(2)— call our western —(3)—, a lovely damosel known as Linnie R. E. Quashun. No beauty —(4)— nor —(5)— (minus the first s) needed she, for her lips were red as —(6)—, her —(7)— orbs were bright as any —(8)— intelligence —(9)—, her permanent wave was as straight as any —(10)—, and her nose of good —(11)—. Her —(12)— also was the envy of those who knew her, the —(13)— of her shoulders was as bewitching as the —(14)— of her waist was —(15)—, and her —(16)— so small that the size of her shoe was number —(17)—. Indeed, all knew her as a perfect —(18)— —(19)—.

But not all of her charm was in her —(20)—. She was sent to a modern school where she learned many things of no —(21)— value. Her teachers were not only able to correlate, but also to —(22)—. As a result she could discern the —(23)— between a —(24)— and a tree top, a —(25)— and a chair. There was little that was —(26)— to her. She also knew the nature of —(27)—, so that she often went off on a —(28)—, but on the whole, her efforts were more or —(29)— in the same —(30)— as those of her fellow students. This made her reasoning a bit —(31)—; in fact, at times it reached the —(32)— of the ridiculous. But her teachers were —(33)—, and her principal was heard to declare that any —(34)—, however small, if —(35)— to her knowledge, would cause her to —(36)— above —(37)— and well beyond the —(38)—. There were times when she felt that she was going about in —(39)—, that her capacity was definitely approaching a —(40)—. There were even times when she was —(41)— to wish for a better —(42)—, but on the —(43)—, con-

[1] *Am. Math. Monthly*, Vol. 46, 1939, pp. 234-35.

sidering the —(44)— under which she was working, she appeared quite —(45)—. Really, this is only an —(46)— of her charm. She was an —(47)— of all the freak cults of the day.

Dear reader, you must not for one moment be —(48)— that this school did not develop and —(49)— her physical abilities. In the gymnasium, she performed on the —(50)—bars, and in the open —(51)— she was known to prefer ice. "—(52)—, —(52)—", she would cry whenever it was cold enough. At such —(53)— her —(54)— would cover a considerable —(55)— of time. Her movements were found to —(56)— perfectly. Socially her charms were even —(57)—, for each afternoon the dean served —(58)— and tea from a —(59)— on a small —(60)—. At such times she loved to dance, and as she seized her friend Ho —(61)— De Rhomboid, a —(62)— if there ever was —(63)—, for the swing, she would whistle "—(64)—".

But the —(65)— of all evil was the high —(66)— of her car. No one was able to —(67)— its speed, least of all the —(68)— who changed the —(69)— for her. This frequently —(70)— her to tears; but, nothing daunted, she filled her —(71)— (minus the rhom) with her friends and sought a —(72)— of new adventures. Even with their combined —(73)— knowledge, many considered this —(74)— off their —(75)—. This, no doubt, was due to the —(76)—, a —(77)— for which there is no —(78)—. They must have been —(79)—; you can see for yourself that there was little —(80)— to their procedure.

One day her father, who paid all the bills, came to investigate her education and training. "—(81)— spend my money like this," he lisped. "I must —(82)— her stay in school. She must be —(83)— with me at any —(84)—. He packed her —(85)— and —(86)— home, so that others might say —(87)— things about her. For even when his regard for her was at a —(88)—, his hopes —(89)— about her. Her opinion —(90)— with his, so with a

—(91)— she spent the —(92)— of her days resting, sometimes —(93)—, but usually —(94)—. And herewith endeth this —(95)—. (Answers are given on page 37.)

A fundamental distinction between mathematics and the other arts should be at once apparent. The painter says "Behold!" The musician says "Listen!" We behold and listen and what we see and hear are objects created for our senses to feed upon by the instrumentality of paint and of vibrating bodies. We who behold and listen need not understand the technical means by which the beauty was wrought into existence in order to enjoy it. We may be, and I believe most people are, entirely passive recipients. The mathematician, too, says "behold," and "listen," but we see now with the inward eye of studious and cultivated contemplation and the music we hear is the silent harmony of ideas. When this harmony is disrupted, as in the ugly clash of conflicting statements, we are pained as by a raucous discord on a piano.

—A. E. STANILAND.

Bait the hook well; this fish will bite.

—SHAKESPEARE.

=▽=

Which is the better salary, \$1,000 a year rising \$200 annually, or \$1,000 a year rising \$50 semi-annually?

=▽=

Take six matches, breaking each of two matches into two equal pieces. Now inclose three equal squares with the eight pieces.

=▽=

$$3^3 + 4^3 + 5^3 = 6^3.$$

=▽=

The following is a proof of the Pythagorean theorem which has been attributed to Pythagoras himself:

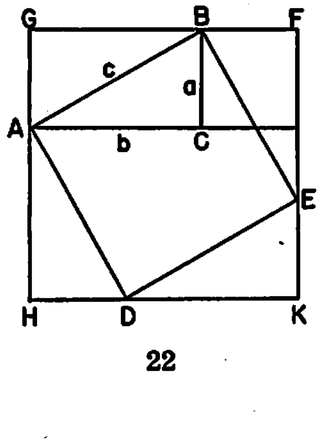
$$ABED = c^2$$
$$FGHK = (a + b)^2;$$
$$ABED + 4ACB = FGHK.$$

Thus,

$$c^2 + 2ab = (a + b)^2,$$

or,

$$c^2 = a^2 + b^2.$$



A hungry hunter came upon two shepherds, one of whom had 3 small loaves of bread and the other 5, all of the same size. The loaves were divided equally among the three, and the hunter paid 8 cents for his share. How should the shepherds divide the money?

—KRAITCHIK, MATHEMATICAL RECREATIONS.

=∇=

"Mathematics is queen of the sciences and arithmetic the queen of mathematics. She often condescends to render service to astronomy and other natural sciences, but under all circumstances the first place is her due." —GAUSS.

=∇=

Euler (1707-1783) was the most prolific mathematical writer of all time.

=∇=

Note that all nine digits occur in the difference,

$$\begin{array}{r} 987654321 \\ \underline{123456789} \\ 864197532 \end{array}$$

=∇=

How many zeros are there at the end of 1000! ?

=∇=

"Guided only by their feeling for symmetry, simplicity, and generality, and an indefinable sense of the fitness of things, creative mathematicians now as in the past are inspired by the art of mathematics rather than by any prospect of ultimate usefulness." —E. T. BELL.

=∇=

2.718281828459045235360 ···

In figures I searched to discover
A sequence in Mystery's knot;
Great Logarithm! nothing will recur
In thy realm but entity Naught!

—SCHOOL SCIENCE AND MATHEMATICS.

The identity,

$$(25 + x)^2 = 100x + (25 - x)^2,$$

is useful for squaring numbers between 25 and 50. Thus,

$$34^2 = 100 \times 9 + 16^2 = 1156.$$

Similarly, numbers between 50 and 75 may be squared by means of the identity,

$$(50 + x)^2 = 200x + (50 - x)^2.$$

$= \nabla =$

"Euler's first paper was published at the age of eighteen. In the succeeding year he wrote on the propagation of sound, and the Paris Academy having offered a prize for an essay on the masting of ships, the young Euler, at the age of twenty and devoid of any practical experience with ships, wrote and had his memoir crowned. He remarked in the conclusion of his essay that he had not considered it necessary to check his results by experiment, for, 'they having been deduced from the surest foundations in mechanics, their truth or correctness could not be questioned.' This was characteristic of Euler's lifelong attitude. He never ceased to regard the deductive power of the mind as of unquestionable supremacy, and if the results of a computation clashed with common sense, he never hesitated to support the former."

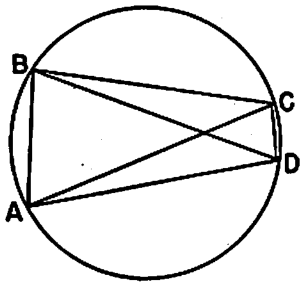
—R. E. LANGER.

$= \nabla =$

In a certain country, a person always laughs if he sees a smudge on another person's forehead (and at nothing else). Three men, *A*, *B* and *C*, have smudges, but don't know it. They are all placed in a room and told that anyone can leave as soon as he is positive he has a smudge. They enter the room and all begin laughing. Almost immediately, *A* leaves the room. How did *A* know that he must have a smudge?

The Pythagoreon theorem is a special case of Ptolemy's theorem: If $ABCD$ is any quadrilateral inscribed in a circle, then

$$AB \cdot DC + AD \cdot BC = AC \cdot BD.$$



$= \nabla =$

"The pentagon is the symbol of man, because it is the first form which lends itself to the drawing with it of the figure of a man, which the reader can himself see if he draws a pentagon with five equal sides and places within the head, arms, body, and legs."—W. C. CORNWALL, "The Mystery of Numbers", *Forum,* Sept., 1922.

$= \nabla =$

Find the simplest form of the product,

$$(2^{2^0}+1)\ (2^{2^1}+1)\ (2^{2^2}+1)\cdots(2^{2^n}+1).$$

$= \nabla =$

A question that is frequently propounded concerns the largest number which can be expressed by three digits. The answer is the number

$$9^{9^9};$$

that is 9 exponent 9^9 or 9 exponent 387,420,489. This number is of inconceivable magnitude. It has been partially computed and found to be 428,124,773,175,747,048,036,987,-115,9 $\cdots$ 89, where the three dots indicate 369,693,070 missing digits which have not been determined. If printed with 16 figures to an inch, this enormous number would extend over 360 miles. It has been estimated that the number would fill 33 volumes of 800 pages each, printing 14,000 figures on a page.

=∇=

How far does a chipmunk travel if he runs from one end to the other along the top of a log ten feet long and three feet in diameter while the log rolls down hill fifty feet?

=∇=

There is a remarkable property of fractions contained in a proposition known as Farey's theorem: If all the proper fractions written in their lowest terms, which have denominators not exceeding a given number, be arranged according to their size, then each fraction in the array is equal to the fraction whose numerator is the sum of the two numerators on either side of it, and whose denominator is the sum of the corresponding denominators.

To illustrate this theorem, suppose we choose the number 5; then we write all the proper fractions in lowest terms with denominators 2, 3, 4, and 5, and arrange them according to size: 1/5, 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5. Then, adding the numerators and denominators of 1/5 and 1/3, we have

$$\frac{1+1}{5+3} = \frac{1}{4}$$

Again, adding the numerators and denominators of 1/4 and 2/5,

$$\frac{1+2}{4+5} = \frac{1}{3}$$

It will be left to the reader to verify the theorem for the other fractions in the sequence.

=∇=

Let m/n represent any common fraction which is in its lowest terms. If the denominator has a prime divisor other than 2 or 5, it is impossible to reduce m/n to an exact simple decimal fraction. In such a case, there is always a remainder no matter how many figures are obtained in the quotient. If the division is considered to be carried out to an infinite number of places, a "repeating" or "circulating" decimal fraction results. For example, $1/3 = .3333\cdots$ and $3/11 = .272727\cdots$, where the three dots are read, "and so on." The group of digits which repeats is called the repetend; thus, the repetend of 3/11 is 27. Many fractions do not start repeating at once; for example, $1/88 = .0113636\cdots$. However, it is not necessary to go further than $n-1$ decimal places before coming to the end of the first repetend of m/n. This is easy to see if it is noted that there are only $n-1$ different remainders possible, and as soon as any remainder is repeated in the division the quotient must start to repeat.

Repeating decimal fractions possess many peculiar and interesting properties, particularly if the generating fraction m/n has a denominator which is a prime number. In the discussion which follows, the value of n is restricted to prime numbers different from 2 and 5. The following is a list of repeating decimal fractions corresponding to certain unit fractions. In each case, only the complete repetend is given.

$1/3 = .3\cdots$
$1/7 = .142857\cdots$
$1/11 = .09\cdots$
$1/13 = .076923\cdots$
$1/17 = .0588235294117647\cdots$
$1/19 = .052631578947368421\cdots$
$1/23 = .0434782608695652173913\cdots$
$1/29 = .0344827586206896551724137931\cdots$
$1/31 = .032258064516129\cdots$
$1/37 = .027\cdots$
$1/41 = .02439\cdots$
$1/43 = .023255813953488372093\cdots$

These repeating decimal fractions illustrate the following general principles.

1. The number of digits in the repetend of $1/n$ is either n-1 or a divisor of n-1.

2. If n ends in 1 or 9, the last digit of the repetend is 9 or 1, respectively.

3. If n does not end in 1 or 9, the last digit of the repetend is the same as the last digit of n.

4. If the repetend has an even number of digits, it may be separated into two equal parts such that the corresponding digits in each part add to 9. For example, the repetend of 1/13 is 076923, and $0 + 9 = 9$, $7 + 2 = 9$, $6 + 3 = 9$.

5. If the repetend of $1/n$ contains n-1 digits, then the repetend of m/n contains the same succession of digits but starting with a different figure.

$= \nabla =$

"My model is Euclid, whose justly celebrated book of short stories, entitled 'The Elements of Geometry', will live when most of us who are scribbling today are forgotten. Euclid lays down his plot, sets instantly to work at its development, letting no incident creep in that does not bear relation to the climax, using no unnecessary word, always keeping his one end in view, and the moment he reaches the culmination he stops."

—ROBERT BARR, *Plot of a Short Story.*

$= \nabla =$

I have found you an argument; I am not obliged to find you an understanding.

—SAMUEL JOHNSON.

WHO'S WHO IN KAPPA MU EPSILON

E. R. SLEIGHT ________________________________ *President*
Albion College, Albion, Michigan

FRED W. SPARKS ________________________ *Vice-President*
Texas Technological College, Lubbock Texas

E. MARIE HOVE ________________________________ *Secretary*
University of New Mexico, Albuquerque, New Mexico

LOYAL F. OLLMANN ___________________________ *Treasurer*
Hofstra College, Hempstead, New York

SISTER HELEN SULLIVAN, O.S.B. _________ ____ *Historian*
Mount St. Scholastica College, Atchison, Kansas

O. J. PETERSON __________________________ *Past President*
Kansas State Teachers College, Emporia, Kansas

C. V. NEWSOM ____________________________ *Past President*
Oberlin College, Oberlin, Ohio

J. A. G. SHIRK ___________________________ *Past President*
Kansas State Teachers College, Pittsburg, Kansas

HAROLD D. LARSEN _____________________ *Pentagon Editor*
University of New Mexico, Albuquerque, New Mexico

FRANK C. GENTRY ___________________ *Pentagon Bus. Mgr.*
University of New Mexico, Albuquerque, New Mexico

L. G. BALFOUR COMPANY _______________________ *Jeweler*
Attleboro, Massachusetts

CHAPTERS OF KAPPA MU EPSILON

ALABAMA ALPHA, Athens College, Athens.

ALABAMA BETA, Alabama State Teachers College, Florence.

ALABAMA GAMMA, Alabama College, Montevallo.

ILLINOIS ALPHA, Illinois State Normal University, Normal.

ILLINOIS BETA, Illinois State Teachers College, Charleston.

ILLINOIS GAMMA, Chicago Teachers College, Chicago.

ILLINOIS DELTA, College of St. Francis, Joliet.

IOWA ALPHA, Iowa State Teachers College, Cedar Falls.

IOWA BETA, Drake University, Des Moines.

KANSAS ALPHA, Kansas State Teachers College, Pittsburg.

KANSAS BETA, Kansas State Teachers College, Emporia.

KANSAS GAMMA, Mount St. Scholastica College, Atchison.

LOUISIANA ALPHA, Louisiana State University, Baton Rouge.

MICHIGAN ALPHA, Albion College, Albion.

MICHIGAN BETA, Central Michigan College, Mount Pleasant.

MISSISSIPPI ALPHA, State College for Women, Columbus.

MISSISSIPPI BETA, Mississippi State College, State College.

MISSOURI ALPHA, Missouri State Teachers College, Springfield.

MISSOURI BETA, Missouri State Teachers College, Warrensburg.

NEBRASKA ALPHA, Nebraska State Teachers College, Wayne.

NEW JERSEY ALPHA, Upsala College, East Orange.

NEW JERSEY BETA, New Jersey State Teachers College, Montclair.

NEW MEXICO ALPHA, University of New Mexico, Albuquerque.

NEW YORK ALPHA, Hofstra College, Hempstead.

OHIO ALPHA, Bowling Green State University, Bowling Green.

OHIO BETA, College of Wooster, Wooster.

OKLAHOMA ALPHA, Northeastern State College, Tahlequah.

SOUTH CAROLINA ALPHA, Coker College, Hartsville.

TENNESSEE ALPHA, Tennessee Polytechnic Institute, Cookeville.

TEXAS ALPHA, Texas Technological College, Lubbock.

TEXAS BETA, Southern Methodist University, Dallas.

In most sciences one generation tears down what another has built and what one has established another destroys. In Mathematics alone each generation builds a new story on the old structure.

—HANKEL.

REPORT OF THE NATIONAL TREASURER

LOYAL F. OLLMANN

Your attention is called to the new procedure in making payments to the national officers:

1. For each new initiate, student or faculty, an initiation fee of $3.50 shall be paid to the National Secretary at the time of the application. This fee will take care of all expenses, including a subscription to THE PENTAGON, for a period of two years. There are no further dues for students while attending college.

2. For every old faculty member, the dues are one dollar a year to be payable to the National Treasurer on or before October 1st of each year. This amount will include a subscription to THE PENTAGON. The name and address of each faculty member must be submitted early in the year to assure his receiving copies of all issues.

The following financial report covers the period from November 1, 1944, to October 15, 1945.

RECEIPTS

Cash Balance November 1, 1944	$514.32	
Receipts from Chapters	781.90	
Receipts from PENTAGON fund	115.32	
Interest on U. S. Bonds	35.00	
Total Receipts		$1446.54

EXPENDITURES

Executive Council Expenses	$120.29	
PENTAGON	270.85	
Printed Supplies	26.50	
Total Expenditures		417.64
Cash Balance		$1028.90
U. S. Bonds on Hand		1775.00
Total Balance October 15, 1945		$2803.90

KAPPA MU EPSILON POTPOURRI

SISTER HELEN SULLIVAN, O.S.B.

Due to the fact that many of our chapters are not in a position to operate on a peace-time schedule we have decided to continue our policy of publishing *complete* chapter reports in the spring issue. Our present POTPOURRI column aims to bring to our readers significant news items from each chapter for the period covering the summer months and the first quarter of the present term.

As a result of elections held in early June the following national officers were elected to serve a second term of office:

PRESIDENT: E. R. Sleight, Albion College, Albion, Mich.

VICE-PRESIDENT: F. W. Sparks, Texas Technological College, Lubbock, Tex.

SECRETARY: E. Marie Hove, University of New Mexico, Albuquerque, N. M.

TREASURER: L. F. Ollmann, Hofstra College, Hempstead, N. Y.

HISTORIAN: Sister Helen Sullivan, O.S.B., Mount St. Scholastica College, Atchison, Kans.

The newest chapter to be received into the organization is *Illinois Delta* which was established on May 21, 1945, at College of St. Francis, Joliet, Illinois. The installation ceremonies for the new chapter were conducted by Mr. J. J. Urbancek assisted by Dr. Johnson and three students of Chicago Teachers College. All are members of the *Illinois Gamma* Chapter of Kappa Mu Epsilon. Following the installation of the chapter, twenty members were inducted into the local chapter. Sister Rita Clare is Corresponding Secretary for *Illinois Delta*. No special activities were carried on during the summer session.

Ohio Beta, located at the College of Wooster in Wooster, Ohio, is still unable to function. No mathematics courses were offered during the summer months. The mathematics staff has been almost completely devoted to the Navy program.

New Jersey Beta, Montclair State Teachers College, held three meetings during the summer session. The continuous theme was "Celestial Mechanics" and the following papers were given: "Celestial Sphere" by Betty Wright; "Structure of the Universe" by Jane Wydeman; "Astro-physics and Location of Heavenly Bodies" by Ernest Yeager. Professor Virgil S. Mallory, the faculty adviser, constructed an equatorial telescope on the campus which was used in the location and observation of stars and planets. Dr. Howard F. Fehr is Corresponding Secretary for *New Jersey Beta*.

Nebraska Alpha at Wayne, Nebraska, enjoyed a quiescent summer period and is operating with a "skeleton organization" (two student members) during the present fall term. Indications are good for the reactivation of the chapter in a few months. Former members continue to furnish interesting bits of news. Dean Sandahl was liberated from prison and arrived at his home in Wakefield, Nebraska, on May 2, 1945. Barbara Hook and Mary Claire Jordan are doing graduate work at the University of Iowa.

An optimistic outlook for *Tennessee Alpha* is offered by Professor R. H. Moorman, Secretary Descartes of the local chapter located at Cookeville, Tennessee. It is hoped that regular meetings will be held although the present membership is limited to the six chapter officers. Professor R. H. Moorman has returned to Tennessee Polytechnic after a year's leave of absence during which time he was at the College of Charleston, South Carolina.

Professor H. F. Heller of Eastern Illinois State Teachers College at Charleston, Illinois, expresses regret that *Illinois Beta* is unable to function. A possible group of February initiates gives promise of normal activity in the near future.

From *Michigan Alpha* at Albion College, Albion, Michigan, come this interesting news report. Mr. William

Vogelsong '44 and Mr. Kenneth Ferguson '44 helped at Oak Ridge in the production of the atomic bomb and merited high commendation by their superior associates. Assisting in basic research concerning the development of the atomic bomb were Mr. Paul Dunn and Miss Clare Stanford, both members of *Michigan Alpha*. Miss Suzanne Porter, a Phi Beta Kappa student, is doing graduate work at Cornell University.

New Mexico Alpha, at the University of New Mexico in Albuquerque, is honored in having as its chapter sponsor this year the National Secretary of Kappa Mu Epsilon, Miss E. Marie Hove. In the past two terms the following papers were given: "Tesselations" by Mrs. Eupha Buck Morris; "The Binary System of Notation" by Dr. Harold D. Larsen; "Numerology" by Mr. A. Zeller; "The Central Valley Project" by Mr. Marvin May; "Functions of the Polar Planimeter" by Dr. Arthur Rosenthal; "Photogrammetry" by Mrs. Ruth Kendrick; "Mathematics and Student Health" by Mr. J. J. Heimerich.

Texas Alpha, located at Texas Technological College in Lubbock, introduces its new faculty sponsor, Miss Virginia Bowman, who succeeds Dr. D. L. Webb. Miss Bowman received her A. M. degree in mathematics at Texas Technological in 1945 and is an assistant instructor on the mathematics staff of her Alma Mater. Lt. R. E. Michie, a charter member of *Texas Alpha*, who has been a Japanese prisoner for more than three years, was liberated in Manchuria by the Russians in September, 1945. He joined his parents in San Francisco, California, on October 1st. Sarah Scroggins Swafford has returned to Texas Technological to finish her college course.

Kansas Alpha Chapter at the State Teachers College in Pittsburg, Kansas, boasts of having initiated one hundred Navy V-12 men during the time the unit was on the K. S. T. C. campus. Miss Marie Cowley, charter member of *Kansas Alpha*, is teaching mathematics at the Senior High School in Edmonds, Washington. Mrs. Dorothy Breiner-Bradshaw, Chapter President '44-'45 is teaching mathematics at the Junior High School in Pittsburg, Kansas. Professor R. W. Hart, on leave from the mathematics staff at K. S. T. C. since '41, is employed in the Demobilization School at Great Lakes Naval Training Station.

Illinois Gamma at Chicago Teachers College reports a very active chapter. The average attendance at the regular meetings numbers in the thirties. A very interested and scholarly spirit prevails. The following papers were presented: "Time—The Fourth Dimension" by Bernard Malina; "The Law of Probability and Combination" by Dr. E. C. Colin; "Mathematical Recreations" by the faculty sponsor, Mr. J. J. Urbancek.

Kansas Gamma Chapter at Mount St. Scholastica College, Atchison, Kansas, reports a very active summer session. Sarah Alice Woodhouse Sheehy, first president of *Kansas Gamma*, is doing work at the University of California. She reports having attended a lecture on "Atomic Fission" given before the American Society of Physics Teachers in Los Angeles. Miss Bobbe Powers, charter member of *Kansas Gamma* and chapter president in '41-'42, was married May 25th to Cpl. Daniel F. Beattie, U. S. M. C. At present they are living in Vicksburg, Virginia.

A last-minute flash from *New Jersey Alpha*, Upsala College, East Orange, New Jersey, brings this news: Anne Zmurkiewcz, chapter president '41-'42, was married on September 15th to Mr. Gerald B. Bodnar of Newark, New Jersey. Betty Rudebock, chapter president '44-'45, was awarded a fellowship in mathematics to the University of Maryland and is pursuing graduate work in that institution.

Mississippi Alpha, at Mississippi State College for Women in Columbus, sponsors a mathematics club in addition to the regular fraternity chapter. Papers combining mathematics and history are usually presented. *Mississippi Alpha* is proud to report that former members have done statistical work in connection with the production of the atomic bomb. The fraternity chapter numbers twenty active members who assemble regularly for varied and interesting meetings. Frances Graham, chapter president, '44-'45, is employed in the Research Department of the Louisiana Oil Company.

ANSWERS TO THE MATHEMATICAL SAGA

1. regions
2. sum
3. planes
4. operations
5. slipstick
6. radicals
7. elliptical
8. high
9. quotient
10. line
11. proportion
12. figure
13. slope
14. circumference
15. infinitesimal
16. foot
17. nine
18. thirty
19. six
20. curves
21. mean
22. integrate
23. difference
24. root
25. table
26. unknown
27. proof
28. tangent
29. less
30. plane
31. indeterminate
32. height
33. satisfied
34. increment
35. added
36. function
37. normal
38. subnormal
39. circles
40. limit
41. inclined
42. perspective
43. whole
44. system
45. rational
46. index
47. exponent
48. positive
49. multiply
50. parallel
51. spaces
52. lemniscate
53. times
54. demonstration
55. period
56. coördinate
57. greater
58. pi
59. hypotenuse
60. table
61. ratio
62. locus
63. one
64. logarithm
65. root
66. power
67. compute
68. mechanics
69. differential
70. reduced
71. rhombus
72. series
73. maximum
74. group
75. base
76. altitude
77. problem
78. solution
79. irrational
80. continuity
81. secant
82. terminate
83. square
84. rate
85. properties
86. center
87. complementary
88. minimum
89. revolved
90. coincided
91. loci
92. remainder
93. vertical
94. horizontal
95. exercise

INFORMATION FOR VETERANS[1]

Questions and Answers About G. I. Bill 346:

The following questions and answers are for veterans who are interested in filing claims under the G. I. Bill (346).

Q—Is there any way in which I can qualify for benefits under this bill on fewer than ninety days' active service?

A—Yes, if you were discharged on account of an injury or disability actually incurred while in service.

Q—What if I was twenty-five years of age when I entered service?

A—Then you must convince the Veterans Administration that your education or training was actually interfered with.

Q—Suppose the Administration decides that my education or training was not interfered with?

A—You will still be entitled to one calendar year of education or training.

Q—If it is decided that my education or training was interfered with, to how much education or training will I be entitled?

A—To one year plus the time you spent in active service.

Q—What educational institutions may I select?

A—Any that will accept you.

Q—How soon must I claim my rights under the G. I. Bill?

A—Not later than two (2) years after date of your discharge from service or the close of the present war, whichever is the later.

Q—How long will this opportunity for training be open to me?

A—For seven (7) years after the close of the present war, but you must present your claims within two (2) years after your discharge or the close of the war, whichever is the later.

Q—What is the longest period for which a veteran may procure education or training under the G. I. Bill?

A—Four (4) years.

Questions and Answers About the Vocational Bill

If you intend to apply under Public Law 16 (Vocational Rehabilitation), study the following questions and answers.

Q—How long must I have served in order to be eligible for vocational training under this bill?

A—So far as length of service is concerned, you are eligible if you have served in either the army or navy at any time between September 16, 1940, and the close of the present war.

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1 From the University of New Mexico Bulletin, 1944-45.

Q—Must I be eligible to a pension before I can claim under this law?
A—Yes.

Q—Would such eligibility alone qualify me for benefits?
A—No. Your disability must be one which the Veterans Administration considers a vocational handicap.

Q—Must the disability have been incurred while I was in service?
A—Not necessarily. It might be a disability which existed when you entered the service, but has been aggravated by your service duties.

Q—To how much vocational training am I entitled?
A—To whatever amount (not to exceed four [4] years) the Veterans Administration considers necessary to fit you for gainful employment.

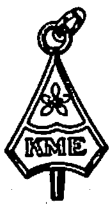
Q—How long may I wait before applying for benefits under this bill?
A—The law goes out of effect six (6) years after the close of the present war, but applications should be made early.

Q—What training institution may I enter?
A—Any one in your own state or in the region of the Veterans Administration in which your home is situated, or elsewhere if approved by the regional chief of the vocational rehabilitation and education division of the Veterans Administration.

Q—What studies or course of training may I select?
A—Any that the Veterans Administration will approve.

Q—To what financial benefits am I entitled while I am in training?
A—Allowance for all necessary tuition, fees, textbooks, supplies and equipment will be made to the institution or training agency in which you are enrolled.

Q—Do I receive any compensation?
A—Yes, a monthly pension.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