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Title of Study: WHY A THOROUGH STUDY OF MATHEMATICS SHOULD BE MADE
IN HIGH SCHOOL IF PREPARING FOR AN INTENSIVE STUDY
OF NATURAL SCIENCE OR ENGINEERING IN COLLEGE.

Pages in Study: 32 Candidate for Degree of Master of Natural Science

Major Field: Natural Science

Scope of Study: Studies were conducted in order to determine how important the study of mathematics is to the high school student, if intending to enter the field of natural science or engineering, and to determine what mathematics courses they should enroll in, in high school, if they are to have the prerequisites by the time they reach the second semester of their freshman year in college. A study was made of the economy of, and advantages gained, by taking high school courses in high school instead of waiting until they reach college.

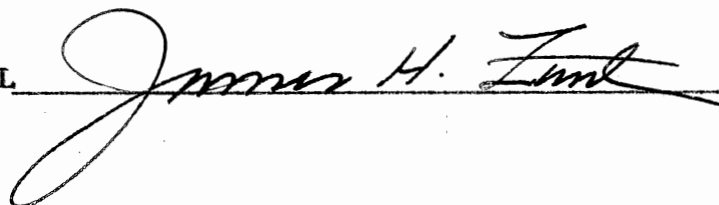
Findings and Conclusions: Mathematics is a prerequisite to all phases of natural science and engineering, in fact, mathematics is the very foundation of the above mentioned college fields of intensive study.

Colleges and universities of Oklahoma are in a squeeze between the great number of students enrolling and the necessary finances for classrooms, additional instructors and other factors introduced by the large enrollment.

Leading colleges and universities are having to teach too many students courses that they should have had in high school. As a result some colleges and universities are rejecting students without the necessary background and it is highly possible that most of the remaining educational centers will have to do the same in the near future.

The national enrollment in mathematics courses in high school is very low, percentage wise, this occurring in high schools that offer the courses, therefore it is necessary to motivate the students in order to eliminate this predicament.

ADVISER'S APPROVAL


James H. Lunt

**A SEMINAR STUDY ON WHY A THOROUGH STUDY OF MATHEMATICS
SHOULD BE MADE IN HIGH SCHOOL IF PREPARING FOR
AN INTENSIVE STUDY OF NATURAL SCIENCE
OR ENGINEERING IN COLLEGE**

By

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**Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF NATURAL SCIENCE
May, 1957**

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Report Approved:


Report Adviser


Dean of the Graduate School

PREFACE

The intent of this report is to indicate the necessity of making a thorough study of mathematics in high school if the student chooses to pursue an intensive study of natural science or engineering in college.

Students must make their decision early as to their life's work, and if they are presented with the requirements, they will have to meet, a much wiser decision should result.

The lack of interest in mathematics and science was one of the factors in the establishment of the National Science Foundation Supplementary Training Program for High School Science Teachers and various grants and scholarships to superior students. As a result, I have made several references to various articles and publications and instead of using footnotes, have included a bibliography.

I am deeply indebted to many individuals for their co-operation in the preparation of this report. The constant encouragement and co-operation of Dr. James H. Zant, adviser and director of the National Science Foundation Supplementary Training Program for High School Science Teachers; Dr. Gordon G. Smith, Professor of Civil Engineering; and to the members of the National Science Foundation Supplementary Training Program for High School Science Teachers for their inspiration, constructive criticism and interest in this report.

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CHAPTER I

INTRODUCTION

Start Planning Now For Your Career.

The subjects you take now, and the grades you get in them can mean success or failure in your later life. There are two kinds of jobs; (1) those that require a special training or skill and (2) those that do not. Workers are divided into two similar groups; (1) skilled and (2) unskilled. In days when things were comparatively simple, most of the people who worked were of the unskilled type with very few skilled workers. Those days did not last very long, in fact, in the last 17 years great strides have been made in all types of livelihoods, from farming in the scientific manner to the more complex industries. A farmer, who in this day and age uses hit and miss, buggy day methods is not likely to get far when in competition with the modern scientific farmer. The scientific farmer will have superior seeds, crops, animals, time saving devices, and chemicals in disease and weed control with which the unskilled farmer cannot compete. "The common laborer is on his way out and will be replaced by a technician in the fast approaching age of automation. To meet the demand for the army of technicians that will be needed, mathematics teachers must take a more practical approach to their subject."^[17]

Since there is such a large demand for skilled workers, it is

getting increasingly harder and harder for the unskilled laborer to locate a job. It is important that you give serious thought about what you are going to do for a living some day. You should decide on which type of work you are most interested, for that is the type of study and work in which you will be most successful. Your guidance counselor should be interviewed and a decision reached in your early days of high school. Of course, you will be interested in training for the better paying positions but money is not everything -- you will be happier with work in which you have the most interest and, as mentioned before, you will be more successful in that field.

The fellow who wants to be an engineer, chemist, physicist, teacher, business man, administrator, agriculturalist, doctor, veterinarian, geologist, or any other line of specialization must have a foundation in mathematics.

Are You Sure You Can Go to College?

There was a time when all a person needed to go to college was a high school diploma and the necessary finances, however times have changed and are still changing at a fast tempo.

Let's take a look at some of the items that have caused the "squeeze" in college enrollment today; and which, apparently, will increase as the years roll by and you are ready for college; (1) more people want to go to college -- with our increasing population and the tremendous increase in population as a result of the war years and immediate post war years, classroom space is inadequate to serve everybody that wants to go. (2) Our increase in incomes enables more families to send their children to college. This puts

an additional load on the already scarce classrooms. (3) The increase in the demand by business and industry for skilled personnel, with their higher salary scale, has taken many of the qualified teachers, thus leaving colleges short of trained personnel.

What Background is Essential.

As a result of the above items, not everybody who wants to go to college will be able to do so. The winners in this mad scramble will be those with good to above average in scholarships and a solid background of subject matter. The subject matter, by courses, will depend on the particular line of intensive training that the individuals desire. A thorough background in English, social science, science, and mathematics will be the most desirable. The latter two will be a necessity if the student desires intensive training in the fields of natural sciences or engineering.

Oklahoma State Appropriations.

The writer was able to pick up a leaflet in the Student Union Building at Oklahoma A. and M. College, the contents of which are: "During the last three years, enrollments have increased 36 percent in the colleges of Oklahoma. During that period appropriations for support of colleges increased only seven percent. The state budget officer's recommendation for the new biennial appropriation for colleges call for increases in operating funds of only four percent.

RECOMMENDED INCREASES BY PERCENTAGE

Highways	21%
Mental Health	15%
Public Safety and Defense	13%
Common Schools	12%
General Government	8%
Higher Education	4%."

Why Some Students Are Denied College Admission.

"Why will some prospective students be denied admission to college? Sixty-one and one-half percent of those rejected were for the reason of ranking low in their high school graduating class. Twenty-five and one-half percent were turned down for lack of specific subject matter. Only 13 percent of the applicants were actually lacking in ability."^[11]

"The chief reasons for the denials, for college admission," says the admissions officer of Illinois Institute of Technology, "rests on the applicants inadequate preparation in mathematics and science. Many of these rejected students were also ill-prepared in English, including the lack of ability to read with ease and proficiency. Approximately 75 percent of the denied applicants involve relatively poor background in mathematics. About 30 percent of the denials are related to inadequate preparation in physics and chemistry."^[13]

"Seventy-eight prominent college admissions officers revealed that high school students may not be accepted if they are not in the upper half of their graduation class."^[14]

Not all major colleges and universities reject students but in the future a great many, if not all, major ones will be forced to do so, due to the following reasons: (A) As stated before, they are overloaded with students due to increased number of high school graduates, and the increased financial means of the average American family. This demands a great increase in the number of classrooms necessary and a corresponding number of qualified teachers. (B) The institutions are unable to get the appropriations for the expansion

necessary to build the classrooms and the additional number of professors with advanced degrees. The foregoing causes a heavy drain on their budget and forces a halt when the maximum is reached. Of course, when the institutions have to make rejections they will reject those less suited to their qualifications. They are accepting those in the upper half of their graduating class and who have taken the necessary solid courses in high school. Colleges and universities have found that the chances for an individual to succeed are almost directly proportional to the quality of work he has done in high school. The four-year period represents a record of the student's attitude toward his work, the effectiveness and efficiency with which he can perform, and the study habits which he has acquired.

Anyone not presenting two and one-half credits in mathematics is practically doomed to rejection, if working in natural science and/or engineering. So much emphasis is placed on mathematics because it is the foundation to practically all major fields of study, and must be taken sooner or later. Most of the major colleges and universities that are not, as yet, rejecting applicants, have more than fifty percent of their freshmen in high school courses, a feature they cannot afford financially, especially since these courses should have been taken while in high school.

"A large university reports that one-third of its freshmen who desire to pursue scientific studies found it necessary to take high school mathematics in college."^[4]

"One educator told congressmen about two schools of engineering, at State universities, where 61 percent and 72 percent respectively of the freshmen had to take remedial training in high school mathematics."^[8]

"The National Society of Professional Engineers is alarmed at the lack of interest young people are showing in the study of mathematics. The society reports that only 25 percent of high school students are now studying mathematics in high school. Probably only 12 percent study chemistry and geometry, and the interest in physics and chemistry is so small that many high schools do not have the courses."^[22]

Why Should I Take Mathematics In High School.

A student may ask, "Why should I take mathematics or physics in high school when I want to major in one of the liberal arts in college?" Too often a student comes to college with a block against mathematics or the sciences. The preparation for college must include an understanding of the fascinating aspects of the scientific frontiers as well as the vocational opportunities presented. ". . . then it began to be apparent that high school mathematics was one of the more important training fields, if not the most important for scientists and engineers. It is probably more important than high school sciences and almost certainly more important than college mathematics in setting up a career in science or engineering. It soon became apparent that the high school was the place to look for an increased supply of scientists."^[7]

Dr. Robert MacVicar had this to say, "The concepts of scientific problem solving must be built into the school curriculum to bring education up to date. We have a horse and buggy curriculum in a jet propelled age. It is nobody's fault in particular. It is a result of the changes taking place in the world we live in."^[16]

"For several years, especially the past few years, college and

university faculty members have been concerned with the apparent lack of mathematical competence evidenced by many entering freshmen. Various tests and surveys have been taken and results correlated. A particular one was conducted at the University of Cornell and given to a group of students of which 99 percent had taken at least one course in mathematics, 95 percent had taken two, 69 percent had taken three, 32 percent had taken four, and 15 percent had taken more than four. It is clearly seen that the above group of students had been exposed to a sufficient amount of mathematics."^[9] The result of the test, for the group as a whole, indicated the group needed remedial study.

"Without necessary educational background -- and math as the basis of this -- it is impossible to progress to the job that means more pay, more security and less hard uninteresting work."^[2]

Another item to be considered is the relative importance of enrolling in the courses. If colleges are concerned about mathematical deficiencies in a group with an apparent solid background, what about you, the average high school graduate with only one unit of mathematics?

Apparently, it is the modern opinion that regardless of how much high school mathematics a student has in his senior year of high school, he should enroll in a comprehensive course -- reviewing all mathematics and arithmetic.

Harrison Geiselman has this to say: "One possibility would be a senior mathematics course reviewing the everyday essentials of arithmetic and mathematics on a mature level. Otherwise, students will continue to graduate, inadequately prepared arithmetically

simply because they have forgotten the fundamentals through disuse."^[10]

Harriette Burr has this to say about the low level of the graduated high school student: "How does it happen that 50 percent of the high school graduates can only reach sixth grade achievements in mathematics. If 55 percent of the schools offer at least two semesters of non-college mathematics after the ninth grade, shouldn't the high school graduate reach a higher level of attainment? The answer seems to be that the high school students do not elect mathematics even if available."^[6]

Trends in National Enrollment in Mathematics.

Table I

"Percentage of high school enrollment in algebra, geometry and trigonometry by years."^[5]

Year	Algebra	Geometry	Trigonometry
1890	45.4	21.3	1.9
1900	56.3	27.4	1.9
1910	56.9	30.9	1.9
1915	48.8	26.5	1.5
1922	40.2	22.7	1.5
1928	35.2	19.8	1.3
1934	20.4	17.1	1.3
1949	26.8	12.8	2.0
1953	24.6	11.6	1.7
1955	24.8	11.4	2.6

The above percentages were based on the number enrolled in the classes, respectively, in that particular year. For instance in 1890, 45.4 percent of the ninth graders were enrolled in algebra; 21.3 percent of the sophomores were enrolled in geometry and 1.9 percent of the juniors and seniors enrolled in trigonometry.

Further study revealed that 37.4 percent of the high school

graduates will have had plane geometry; 44.5 percent will have had general mathematics; 64.5 percent will have had Algebra I; 28.5 percent will have had Algebra II and 13 percent will have had trigonometry and/or solid geometry.

Median Incomes.

The 1950 census report tells us that in 1949, of all men 25 years and older, those who completed eight years of grade school received a median income of \$2,533. Those with four years of high school received a median wage of \$3,285. Those who stuck out four years of college received a median wage of \$4,407.

Now money is not the chief aim of life. Yet without it, your life partner will experience worry and monotonous toil. Your own children will not have their share of the good things of life. You and your family will not have a good house in a good neighborhood. You will probably reproach yourself for not being able to provide your dependents with the things which, in your honest moments of self-analysis, you know you owe them.

How many more years are you going to spend in the class room? It all, of course, depends on how much education you are going to get. Regardless of which path you take, you will sooner or later be out on your own.

Have you any idea what you will be doing for a living? Perhaps you do not care; maybe you do not want to be bothered about it now. If you feel this way about it you could be wrong, for it will be a tremendous advantage to you to think about it now, while you are in high school. How will you feel when you face your admissions officer? This matter rests with you, let us get organized before it is too late. Your chance comes but once in a life time.

A Memorandum From The Atomic Energy Commission.

"Whether one aspires to become a scientist or an engineer, the training in high school may be the same. The immediate requisites are mathematics and science. In mathematics, one should master algebra through quadratics, plane and solid geometry, and trigonometry. The important sciences are physics, chemistry, and biology. Time may not permit the high school student to schedule all of these sciences, nor would I urge him to sacrifice other important subjects -- such as English, history, languages, and the social sciences -- in order to study all three of these natural sciences. However, the really serious student should undertake to build this foundation in mathematics and as much science as possible, without neglecting the humanistic studies which are so important in the art of living.

"Never before in the history of the world have such exciting professional adventures been available to well-trained young men and women as exist in this new age of atomic energy. Physicists, chemists metallurgists, mathematicians, biologists, and engineers -- all have an important and challenging role to play in the years ahead. To achieve the stature required, one must commence his training in high school so as to build a firm foundation in science and mathematics. Only if the pupil finds these subjects both interesting and absorbing should he contemplate a professional career of research and development in the rapidly expanding field of atomic energy."^[1]

CHAPTER II

MATHEMATICS: THE FOUNDATION OF NATURAL SCIENCE AND ENGINEERING

Importance of Mathematics.

Mathematics is going to be important to you no matter who you are or what you expect to become after school. Some people can get along with nothing more than arithmetic, others need algebra, geometry or both. A large percent need much knowledge of mathematics, like trigonometry and calculus and more. Business and industry today are fairly complicated. The demand for technicians and engineers exceeds greatly the source of supply.

To be a druggist, you have to be a chemist and to understand chemistry, a knowledge of algebra is necessary. To be a nurse, you must know the biological sciences, such as bacteriology and how to mathematically figure out doses and solutions of chemicals, medicines and similar things, which also include a thorough understanding of mathematics for technicians, engineers, chemists and physicists.

Days were when the farmer could recondition his auto or tractor motor on the farm. Today it takes a technician or specialist to accomplish tasks that in the past an unskilled person could perform, due to the increased precision of machines. He has to understand and operate complicated tools and machines, for all of which an understanding of algebra and geometry is necessary.

To get this training in college, let us take a look at the mathematics entrance requirements and the mathematics courses that will be necessary as you proceed through college.

**A LIST OF MOST OF THE MATHEMATICS COURSES
WITH PREREQUISITES**

<u>Course</u>	<u>Prerequisite</u>
High School Courses	
Algebra I	Grade School Arithmetic
Algebra II	Algebra I
Plane Geometry	Algebra I
High School Trigonometry	Plane Geometry and Algebra I
College Courses	
Solid Geometry	Plane Geometry
General College Mathematics	Algebra I
Intermediate Algebra (equivalent to Algebra II)	Algebra I (equivalent)
College Algebra	Plane Geometry and Algebra II
College Trigonometry	Plane Geometry and Algebra II
Analytic Geometry	College Algebra and Trigonometry
Calculus (elementary)	Analytic Geometry
Calculus (intermediate)	Calculus I
Advanced Analytic and Calculus	Analytic Geometry and Calculus
Theory of Equations	Calculus and Analytic Geometry
College Geometry	Plane Geometry
Solid Analytic Geometry	Theory of Equations
Differential Equations	Calculus and Analytic Geometry
Advanced Calculus	Calculus and Analytic Geometry
Vector and Tensor Analysis	Calculus
Advanced Eng'r. Mathematics	Differential Equations
Introduction to the Theory of Matrices	Theory of Equations
Fluid Dynamics	Advanced Calculus and Vector and Tensor Analysis
Theory of Functions of a Complex Variable	Advanced Calculus or Advanced Eng'r. Mathematics
Partial Differential Equations	Advanced Calculus and Vector and Tensor Analysis

Engineering Prerequisites.

"(1) It is recommended that students who wish to enroll in Oklahoma Institute of Technology take physics and chemistry in high school.

"(2) The first enrollment in an algebra course prior to the algebra placement test is as follows:

"(a) Less than one unit of high school algebra you must take mathematics 145 (beginning and intermediate algebra).

"(b) One and one-half units or more of high school algebra, take mathematics 165 or 173 and 183. (College algebra and trigonometry; college algebra; trigonometry respectively.)

"Mathematics 145 (beginning and intermediate algebra) 143 (intermediate algebra) or mathematics 103 (plane geometry) used to make up deficiencies in algebra and plane geometry cannot be used for meeting the requirements for graduation.

"Prospective students are advised to complete one unit of plane geometry before enrolling in college. If they are deficient in this subject they must complete mathematics 103, (plane geometry) before enrolling in mathematics 165 (college algebra and trigonometry) or mathematics 183 (trigonometry). Although not required, it is urged that solid geometry be taken in high school.

"It is recommended that mathematics 413 (differential equations) and mathematics 443 (advanced engineering mathematics) be taken as elective courses in those curricula where it is not required."^[19]

"For a student entering Oklahoma Institute of Technology, without choosing a particular or specific field, the general curricula is the same even if a specific field is chosen.

"Below are the listings for only mathematics and science courses for engineering students for the first semester of the freshman year:

First semester:

Mathematics 173, College Algebra

Mathematics 183, Plane Trigonometry

or Mathematics 165, (College Algebra and Trigonometry)

Chemistry 114, General Chemistry."^[20]

For the second semester and following semesters the requirements vary, depending on the intensive line of study chosen. "If enrolled in Agricultural Engineering, the second semester, freshman year courses of mathematics and natural science are Mathematics 205 (Analytic Geometry and Calculus), and Chemistry 124 (General Chemistry). For the first semester sophomore year; Mathematics 225 (Calculus) and Physics 215 (Mechanics, Sound and Heat)."^[21]

In checking the remainder of the bulletin the various departments list the same general requirements.

Analytical Geometry and Calculus should be in the student's program by second semester of his freshman year. By referring to the chart that follows, you will see why mathematics is necessary in high school.

"The professional education of the engineer does not start in the university, it starts in the high school. The most important contribution of the high school to the engineer's education is the work in mathematics.

"Action on this assumption the college of engineering of the University of Illinois is increasing its entrance requirements in mathematics. Beginning in 1953, freshmen will take analytic geometry

in the first semester. This will permit them to study calculus in the second semester. Effective September 1, 1953, the regular four-year curriculum of the college of engineering will begin with analytic geometry. There will be two methods of admission to full standing in the college of engineering of the University of Illinois:

Algebra	1 unit
Solid Geometry	1/2 unit
Trigonometry	1/2 unit

"As an alternative to the procedure named above, students who do not submit four units in the specified subjects but who meet all other requirements may be admitted to full standing by passing a proficiency examination which will indicate that their preparation is adequate for entrance to analytic geometry."^[15]

A Tree of Mathematics For Engineering

Vector and Tensor Analysis

Advanced Calculus

Theory of Equations

Differential Equations

College
or
University
Study

Calculus I, II

Organic Chemistry

Advanced Physics

*Analytic Geometry

Inorganic Chemistry

College Physics

College Algebra

College Trigonometry

Solid Geometry

High
School

Trigonometry

Chemistry

Physics Slide Rule

Algebra II

Plane Geometry

Algebra I

Grade
School

Arithmetic

*An Engineering student should be enrolled in Analytic Geometry the second semester of his freshman year.

The School of Technical Training.

This school was set up to train men and women for occupations which have a position between highly scientific professions and the skilled crafts. Research shows that for every engineer in industry there is a need and demand for from five to eight technicians.

The training period is from one to three years, with a two year program at Oklahoma A. and M. College. The curricula contains:

Air Conditioning and Refrigeration

Aviation Technician Training

Automotive Technology and Service Management

Building Construction

Diesel and Stationary Engines

Drafting and Design

Electrical Technology

Fire Protection

Machine Shop

Radio and Electronics

Welding and Metallurgy

Admission to one of the above curricula requires a high school diploma, however, under special circumstance, exceptions may be made. In general, Algebra I, Algebra II, plane geometry, physics, and chemistry courses in high school would be an invaluable aid in these courses, however, they are not required for admission. During your study in one of these departments a few or all of the above mentioned courses will be studied.

A Word About Physics and Its Prerequisites.

Physics, one of the most basic of the sciences, deals with energy

in all its forms, with the inter-relations of matter with energy, and with the structure of matter, and is the foundation on which engineering and all technology are built. Physics, with its companion science chemistry, has probably exerted a more powerful influence on the cultural, intellectual and economic life of the world over the past thirty years than has any other human activity.

Prior to World War II, employment of physicists was mostly in teaching, although the use of physicists in industrial laboratories already had begun to increase at the beginning of the emergency period. Of the physicists, who have the doctor's degree today nearly half are employed by educational institutions, nearly one-fourth by industry and about one-tenth by government. The United States Civil Service lists various grades of professional physicists with base salaries ranging from approximately \$4,400 to \$15,000 per year. In the academic field, salaries are slightly lower, while in industry they are somewhat higher.

Let us take a look at a few elementary physics problems and analyze the mathematics employed.

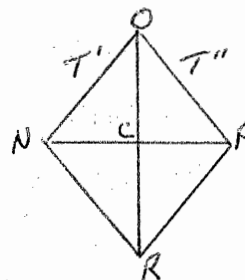
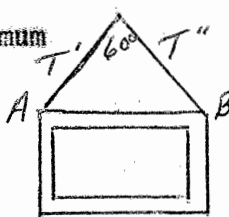
A picture is suspended from a nail as shown. The string will break if a tension of more than 50 pounds is applied. The two halves of the string make an angle of 60°

with the other. Determine the maximum permissible weight of the picture.

Draw a force parallelogram, representing T' and T'' as 50 lbs. each.

The diagonal OR is equal in magnitude

but opposite in direction to the weight of the picture.



In right triangle OCP-----Plane Geometry

$$OC = T'' \times \cos 30^\circ = 50 \text{ lbs.} \times .866 = 43.3 \text{ lbs.} \quad \text{--- Trigonometry}$$

$$OR = 2 \times OC$$

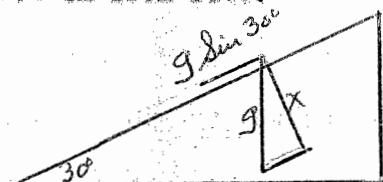
Plane Geometry

$$= 2 \times 43.3$$

$$= 86.6 \text{ lbs.}$$

Algebra I

A body slides down a frictionless incline which makes an angle of 30° with the horizontal. Compute the velocity after sliding 800 cm from rest.



----- Plane Geometry

V = Velocity

A = Acceleration = gravity, $g = 980 \text{ cm/sec}^2$

The acceleration due to gravity may be resolved into two components, perpendicular and parallel to the plane (X and $g \sin 30^\circ$)

$$V = \sqrt{2AS} = \sqrt{2g \sin 30^\circ \times S} \quad \text{----- Arithmetic, Trigonometry and Physics}$$

$$= \sqrt{2 \times 980 \text{ cm/sec}^2 \times 1/2 \times 800 \text{ cm}} \quad \text{----- Metric System}$$

$$= 885 \text{ cm/sec} \quad \text{----- Algebra I}$$

The above examples are of the very simplest physics problems.

In addition to the above items we could add innumerable manipulations involving Algebra II, trigonometry and geometry. A few manipulations would be logarithms, exponential notations, quadratic equations, rectangular coordinate graphing -- complex numbers. It might be well to add that a working knowledge of a slide rule is a valuable, time saving, and otherwise beneficial tool.

The preceeding problems are minute examples of the most elementary physics problems. Needless to say, that as one proceeds upward

through the various courses, the mathematics advances with the physics courses until one proceeds through calculus, differential equations and ever upward.

A Tree of Mathematics For Physics

	<u>Differential Equations</u>	
	<u>Advanced Calculus</u>	
College	<u>Calculus I, II</u>	
Mathematics	<u>Analytical Geometry</u>	
	<u>College Algebra</u>	<u>Trigonometry</u>
	<u>Trigonometry</u>	<u>Solid Geometry</u> <u>Slide Rule</u>
High School	<u>Algebra II</u>	<u>Plane Geometry</u>
Mathematics	<u>Algebra I</u>	

Grade	<u>Arithmetic</u>	
School		
Level		

A Word About Chemistry and Its Prerequisites.

Chemistry is the science that deals with the composition of all substances and with changes in the composition of substances. All matter is made up of extremely small building blocks known as atoms. One job of the chemist is to rearrange the atoms of known substances in order to produce other substances. In this way he can make new materials and improve and modify natural products. Chemists and chemical engineers have cooperated in helping develop thousands of new and useful products which have improved our standard of living.

Now let us take a look at some of the most elementary chemistry problems that beginning college students will encounter.

If a gas containing 50 ml. volume, at 263°A and 745 mm pressure,

is reduced to standard conditions, what is its new volume?

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$\frac{50 \text{ ml}(745 \text{ mm})}{268^\circ\text{A}} = \frac{V_2(760 \text{ mm})}{273^\circ\text{A}}$$

Substitution - Algebra I

$$V_2 = \frac{50 \text{ ml} \times 745 \text{ mm} \times 273^\circ\text{A}}{268^\circ\text{A} \times 760 \text{ mm}}$$

Solving an equation for the unknown - Algebra I and II

$$= 49.6 \text{ ml.}$$

Multiplication and Division - Arithmetic (slide rule)

$$\text{pH} = \log \frac{1}{[\text{H}^+]} = -\log [\text{H}^+] \text{ or } [\text{H}^+] = 10^{\text{pH}}$$

Algebra II

One who has had no contact with chemistry, probably will not understand the above formula equation. However, it is not important here as we are interested in the mathematics -- which we see consists of logarithm and exponential notations (Algebra II). We might sum it up by saying the following type manipulations are needed in chemistry:

1. Significant figures and rounding off.
2. Addition, multiplication, division, and subtraction including fractions and decimals.
3. Exponents.
4. Exponential notations.
5. Logarithm (base 10)
6. Square root.
7. Equations.

The above list is by no means complete; however, it serves the purpose of indicating the very basic mathematical manipulations involved in chemistry. As one proceeds to higher levels of chemistry, a thorough knowledge of mathematics is necessary.

Mathematics Requirements:

College Algebra
 College Trigonometry
 Analytic Geometry
 Calculus (2 courses)
 Advanced Analytics

Prerequisites For Biological Science, Botany, Zoology, Bacteriology and Physiology.

The mathematical requirements are:

General College Mathematics
 College Algebra (needed in order to get the most out of two courses in general chemistry plus additional chemistry)
 College Trigonometry (necessary for the required physics courses)

The above mathematical requirements are to point out, more or less, the minimum mathematical requirements and makes no mention of high school mathematics courses that are prerequisite to these.

Some typical problems taken directly from the above fields follow:

$$(a + b)^5 = a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5$$

The above formula is used in zoology to get the probability that in a family of five, three of the children would be blue eyed and two brown eyed. (Brown eyes are dominant to blue eyes and the parents are heterozygous)

$$10(3/4)^2(1/4)^3 = \frac{90}{1024} = \frac{45}{512}$$

Bacteriology - Convert 1A to Microns. Here a knowledge of the metric system found in physics and chemistry is necessary.

$$1A = 1 \times 10^{-8} \text{ cm} \quad 1 = 1 \times 10^{-3} \text{ mm}$$

$$= 1 \times 10^{-7} \text{ mm}$$

$$1A = 1 \times 10^{-4}$$

The above is typical of some work in the field of biology.

bacteriology, etc., or in any field that requires a study of bacteria or microorganisms.

In the calibration of a microscope in order to measure the size of organisms and making bacterial counts a knowledge of arithmetic is necessary. In this process a calibrated slide is placed on the stage and an ocular micrometer is placed inside the eye piece. After taking readings the ocular divisions are expressed in microns and the field diameter and area must be determined for each of the objective lenses, thus;

49 ocular divisions equal 68 slide divisions

1 ocular division equals 1.38 slide divisions

1 ocular division equals .0138 mm equals 13.8 microns.

After the field diameter is measured, simple arithmetic will give the field area.

Prerequisites For the Field of Physical Science, Geology and Astronomy.

"Physical science covers a general field of chemistry, geology, mathematics, astronomy, statistics and physics. The high school mathematics concerned is Algebra I, Algebra II, trigonometry, and plane geometry plus the college courses of general college mathematics, college algebra, trigonometry, and analytic geometry.

The physical science program is set up for those students desiring a broader program of study in the physical sciences than is afforded by the field of concentration within a single department. It is of special importance to prospective science teachers.

Geology is a study of history of the earth as revealed by its structure and physical makeup. A knowledge of geology is very useful in chemical, civil and petroleum engineering, and agriculture.

Astronomy is the science dealing with the sun, moon, planets, stars and comets. It consists of the study of laws governing their motion and other phenomena such as surface features, composition, size and their effects upon one another.

Astronomy is an interesting study and a hobby of many people, however, it is an invaluable aid to navigators, surveyors, and physicists, also the chemists.

The mathematical requirements for Physical Science is Mathematics 123, (general college mathematics) or 145 (beginning and intermediate algebra).

Beginning and intermediate algebra is equivalent to the two high school courses consisting of Algebra I and Algebra II.

Basic chemistry and general physics are also required, which make the courses of Algebra I and Algebra II necessary from another standpoint.

The mathematics required for geology is: Mathematics 173 (college algebra), Mathematics 183, (college trigonometry); Mathematics 193 (analytic geometry) is a suggested elective.

Calculus may be required, depending on the field of specialization selected.

Mathematics required for astronomy is Mathematics 173 (college algebra), 183 (college trigonometry), 193 (analytic geometry), Mathematics 215 (calculus) or Mathematics 205 (analytic geometry and calculus).^[18] It should be apparent by now that before Mathematics 205 can be taken, there are several prerequisite courses. Can you name them? Which are considered as high school courses?

CHAPTER III

OTHER REASONS FOR ENROLLING IN MATHEMATICS IN HIGH SCHOOL

The Economy of Taking Courses in High School Instead of Waiting Until You Arrive at College.

"Expenses for a year's education at Oklahoma A. and M. College are about the lowest in the nation. The overall cost of education, housing and books is from \$750 to \$900 a year. This includes board and room, books and supplies. The general fee is \$34 per semester.

The general fee is a charge which includes the individual charge previously made for registration, library, general laboratory, health service, and student activity building fee, and the other student service fees and all regular laboratory fees.

Regular semester, (except for veterinary medicine students) - per semester hour - \$7; non-resident - per semester hour - \$11.

Other Expenses.

Books and supplies used by the college may be secured at close to cost at the college bookstore. Additional incidental and personal expenses such as clothing and entertainment will depend upon the choice of the individual student."^[18]

As this is being written, the state legislature is taking action on the appropriations for the various state institutions and appear unable to raise enough funds to meet the budgets of the colleges and universities. It has been reported that enrollment fees will be

increased approximately \$84, for a total of \$168. If this comes to pass the above figures would have to be increased accordingly.

Plane geometry, intermediate algebra (Algebra II), solid geometry and trigonometry carries a total of eleven semester hours. At seven dollars per semester hour this would cost you seventy-seven dollars to enroll in these high school courses, of course all other expenses would have to be taken into consideration. A little mathematical calculations on your part would show that the above listed courses would cost approximately six hundred twenty dollars to earn credit in them.

If a person tried to calculate the approximate cost of obtaining credit in these courses in high school he would have a difficult time as it would be next to impossible to estimate the cost of board and room at home plus the lower clothing expenses, etc., but in the long run a person would have to admit that it would be much more economical to get credit in these courses in high school.

If these courses are not taken in high school, you will find by referring to page 15 that an additional one to three years will be necessary to complete the regular four year course. Now by estimating an approximate cost of \$1,000 per year to attend college plus one to three years late in arriving on the job after graduation at an approximate salary of \$350 to \$500 per month, totals up to \$5,200 to \$7,000 per year. If it should take you an additional three years then you have lost \$15,600 to \$21,000.

College Time Saved by Enrolling in High School Mathematics.

The more fundamental education the high school graduate brings to college the faster they may be able to climb to success.

By reference to the chart on page 15, it is easily seen that without the mathematics and science courses in high school, the student will not be ready to comprehend the regular engineering courses when they should be taking them. For example, the student should be enrolled in calculus during the second semester of his freshman year. To comprehend calculus, rigorous and thorough courses of Algebra I, Algebra II, plane geometry, trigonometry, college algebra, college trigonometry, and analytic geometry are absolutely necessary. Of course, you realize the mastering of these courses in one semester or at most, one year is impossible, thus a regular four year course becomes a five year course, "if" the student's high school background is insufficient.

With the exception of the Technical Training School, the Institute of Technology at Oklahoma A. and M. College requires that the student be enrolled in college algebra, plane trigonometry the first semester of his freshman year and analytic geometry and calculus the second semester of his freshman year. The foregoing is for normal student who will graduate in four years of study. If any of the prerequisites are lacking, then the time taken to acquire these courses will have to be added to the normal four year period.

What are the requirements or prerequisites to analytic geometry and calculus? Perhaps the following diagram will suffice.

Course	Prerequisite
Plane Geometry	One year high school algebra
Intermediate Algebra	One year high school algebra
Solid Geometry	Plane Geometry
College Algebra	Plane Geometry and Intermediate Algebra
College Trigonometry	Algebra
Analytic Geometry	College Algebra and Trigonometry
Calculus	Analytic Geometry

If the college freshman has credit for Algebra I, Algebra II, and plane geometry he should be able to finish in the normal four year period. If not, a minimum of one semester and possibly two will have to be added to complete these courses before proceeding with the normal course.

When Professor Arthur Bestor of the University of Illinois was asked, "Suppose that tomorrow it was decided by all the colleges and universities to turn out scientists, and suppose they made the study of mathematics and scientific subjects a compulsory thing -- would the students who had no background to speak of in those subjects in the public schools and high schools be able to swing those courses? He answered, They could do it by adding two or three years to their college training. By buckling down to some hard work, most of them could probably make up their deficiencies. But only by sacrificing two or three years of their career."^[3]

A Few Words Concerning the Quality of Instruction.

The high school mathematics instructors of today have to meet rigid specifications in order to receive a teaching certificate. They have taken a definite amount of specialized training and have enriched this training by actual experience in the school rooms. Teaching has been chosen as their life's work, they are dedicated to the task, and they have prepared lesson plans far in advance.

Colleges and universities are feeling a pinch from two directions as far as teaching personnel is concerned. First, enrollments have increased approximately 36 percent while increases in their budgets have amounted to approximately seven percent. The future appears even darker. Second, teaching personnel with Doctor's degrees are not plentiful. The small salary the colleges are able to offer is

insufficient to attract enough professors, therefore, colleges and universities have to use senior and graduate students in order to supplement their staff. Ordinarily the student teachers are assigned to teach the lower level courses, especially the so-called high school courses.

With all due respect to the student teachers, for they have performed a wonderful job under the circumstances, it can hardly be said that their teaching, as a whole, could measure up to the proficiency of the high school professor. The student teacher has not completed his education. In many instances he does not know he will have to teach until the class is ready to start or has already started. The writer knows of an instance where the student teacher did not start teaching until one week after classes started. Of course, this student had already enrolled in a full load of courses, and with no advance notice, he could not have been prepared with lesson outlines, etc. With a full load of courses, his time, that he could possibly devote to class preparation, was limited. As a result you should be able to obtain instruction from a higher level in your own high school.

A Few Words Concerning The Time Element.

During your enrollment in Algebra I, Algebra II, and plane geometry, you will spend five hours per week for thirty-six weeks, a total of 180 class hours in each course. If these same high school courses are taken in college you will spend three hours per week for eighteen weeks, a total of 54 class hours. It is readily seen that the high school instructor will have over three times as much time to spend on the course as will the student instructor. From

which class should you be able to gain the greatest knowledge?

Another factor that should be considered is the size of classes.

In an advanced mathematics class in high school the average class enrollment is approximately 20 or less. In college the average class enrollment for the same courses average approximately 45 students.

Now which instructor will be able to give you the most individual attention?

SUMMARY AND CONCLUSIONS

In recent years a significant change has occurred in the number of high school graduates and the number entering college. As a result colleges and universities do not have sufficient number of classrooms, professors and equipment to adequately accommodate them.

Colleges and universities are not getting sufficient appropriations to alleviate the above situation, in fact, in Oklahoma the increase in appropriations is not keeping up with increased enrollment, not considering the increased costs of operation. The situation is further aggravated by the fact that a large percent of the high school graduates do not have an adequate mathematics and science background, causing colleges and universities to have to teach high school courses, thereby increasing the burden on their already overloaded classroom and instructor problem.

This report was written, with the opinion, that if, high school students and parents were presented the facts, a majority of the students would enroll in science and mathematics in high school and due to the demand, those high schools not offering these courses, would do so, thereby reducing the above problems of the colleges and universities and be a tremendous benefit to the individual.

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VITA

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Personal data: Born near Coltry, Oklahoma, April 20, 1914,
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