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EFFECTS OF TWO METHODS OF PRESENTING HOMEWORK UPON ATTITUDE, ACHIEVEMENT, AND PERCEPTIONS OF STUDY HABITS IN A COLLEGE MATHEMATICS COURSE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

David Thomas Hayes, B.S., M.A.T.

The Ohio State University
1972

Approved by

[Signature]
Adviser
College of Education
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CHAPTER I

THE PROBLEM

Introduction

In the spring of 1969 on the Columbus Campus of The Ohio State University, this author conducted a study of the effects upon achievement in mathematics, attitude towards mathematics, and perception of specific study habits in mathematics of different formats of presenting homework assignments to students enrolled in Mathematics 105, a required course for elementary education majors. The results of that study and the experience gained in that pilot study led to an investigation to test the effects of a personalized homework assignment format on students' achievement in mathematics, attitude toward mathematics, and perceptions of study habits in mathematics.

Problem Background

In the last two decades, educators have worked to develop effective curricula for the teaching of mathematics. The concerns of such groups as The Commission on Mathematics (8), CUPM, The Committee on the Under-
graduate Program in Mathematics (10), The National Association of State Directors of Teacher Education and Certification (49), The Cambridge Conference on School Mathematics (20), CUPM Conferences on the Training of Teachers of Elementary School Mathematics (18), and The Cambridge Conference on Teacher Training (19) led to an updating and upgrading of the content in mathematics at most levels. While these committees worked on the new curricula, some of their members expressed concern about how this "new mathematics" was to be taught. Answers to this question supposedly were among the goals of the CUPM and Cambridge Conferences on Teacher Training. However, the recommendations of these two groups were primarily curricular, not pedagogical, in nature. A few educators expressed interest in the homework that would necessarily accompany the new programs. Suppes (32,6), in referring to process models for arithmetic, wrote

On the other hand, there is an inherent conflict between the kind of situation studied in classical learning theory and the kind of learning that takes place in the classroom in learning to do arithmetic or any other standard curriculum subject. This conflict arises from the fact that in subject matter learning we continually present heterogeneous items, often items that are ranged on a scale of increasing difficulty, but most importantly, items that are heterogenous in character. It is a familiar classroom observation that when children are presented arithmetic problems in the same format, for example in column form, or in a fixed equation form horizontally, and no variation is given, then their ability to handle new material in different formats is reduced. On the other hand, consideration of a variety of formats, or
as it would be put in learning theory, a variety of stimulus patterns, is the exception rather than the rule in experimental learning studies.

Suppes is referring to a problem display format. The format for the experimental treatment in this study enlarges this idea to a personalized format. A personalized format of homework is defined as homework that is presented on Xeroxed handouts incorporating test-like questions, references from the students' environment, consolidation of problems and selected answers, and a review of each week's work incorporated into the problems.

Goldstein (21,212) wrote that two very different questions could be asked about the value of regularly assigned, required homework,

The first question: Does it contribute immediately and directly to achievement in the various subjects? This question can be answered fairly easily through properly designed experiments, but the answer may well depend on the subject, the grade level, the type of assignment, and the amount of homework. The second question: Does homework contribute to academic proficiency through a long-term effect on study skills and attitudes? This question is much more difficult to answer because experiments of a few months' duration are irrelevant and pertinent experiments would take years.

This experiment will attempt to provide a partial answer to question one with respect to mathematics at the beginning college level. Information pertaining to the second question will be examined to possibly give direction to studies of longer duration. The Cambridge
Conference on School Mathematics (20,27) reported

Problem material in a mathematics course takes a long time to read, and an even longer time to write. Mainly for this reason, superficial efforts by both authors and reviewers usually put heavy emphasis on the text material proper. We believe that this is the reverse of sound procedure in each case: It is the problem material that the students live with. Obviously this is true in mere drill books, in which the text is all but vacuous. It remains true when the text is intellectually substantial. Psychologically speaking, mathematics is something which people do; it is not something that they receive in a passive sense. We believe that this principle holds even at very high maturity levels where it may not seem to.

To a mature mathematician, no learning process is passive: he is aware of the possibility of alternative treatments; he connects up the new material with things that he already knows; he translates what he hears into his private language; and so on.

Mass education in mathematics now depends on textbooks. Probably this will be true for a long time. If so, the problem material should be considered at least as important as the text proper and it should get at least half of the time and attention of the authors. Even if textbooks become less important, as the qualifications of teachers rise, problem sequences will continue to be crucial; and the job of composing them is so time-consuming that classroom teachers cannot compose them, one at a time, as they go along.

We therefore believe that the composition of problem sequences is one of the largest and one of the most urgent tasks in curricular development.

Obviously problems should illustrate and reinforce the ideas in the corresponding portion of the text. They also should provide a continual review.

These statements seem to say that the student and what he does is a very important part of the educative process, especially in mathematics. The School Mathematics Study
Group (SMSG) and The Cambridge Conference considered types of homework, such as discovery oriented, applications, type of mathematics, etc. but they considered them from a curricular sense. It is naive to limit the study of homework to content; much more is involved. The aspect of that involvement to be examined in this study is the treatment of homework assignments. However there is conspicuously little written into the literature of mathematics education on how homework is to be treated.

Mulry (47,49) stated that several investigations reveal that homework can be most helpful, for some students, at some grade levels and in some subjects. She further stated that the relation of homework to personal and school success is not conclusively known and that a fair analysis of the value of homework cannot be made until further evidence is presented.

The experiment described herein is designed to try to answer such questions as: Can a personalized format of presenting homework assignments affect achievement, attitude, and perceptions of study habits in mathematics significantly? Is a personalized format of presenting homework assignments to students reflected in their placing more importance upon homework as contributing to their understanding of mathematics?

**Statement of the Problem**

Does the use of a personalized format of assign-
ing homework problems provide for higher ranking of importance of homework, greater change in attitude towards mathematics, and greater achievement in mathematics than the "usual" method of assigning mathematics homework problems?

Definition of Terms Used

1. **Personalized format of homework assignments** is that method of presenting homework assignments on Xeroxed sheets which incorporates the following characteristics:
   a) test-like questions
   b) references from the students' environment
   c) consolidating the problems and supplying answers
   d) building a review of each week's work into the problems

   This treatment and the students receiving it will be referred to as "E" and "the E-group" respectively. The following are examples of the personalized homework assignments.

   They are exact duplicates of parts of assignments given to the experimental group. Assignment 13 shows four different ways of framing questions (short answers, multiple choice, true or false, and matching). Assignments 18, 28, and 39 show how references from the students' environment were employed in the exercises.
4. a) Use similar triangles to find the coordinates of the point midway between the points \((x_1, y_1)\) and \((x_2, y_2)\).

b) Use the formula from a) to find the point midway between \((-5, -1)\) and \((9, -3)\).

answers a) \(\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)\)  b) \((2, -2)\)

5. The cost for a new recreational area is estimated to be $7000.00 a square unit. If the area is to be triangular with vertices at \((3, -2)\), \((3, -6)\) and \((7, -1)\), then the estimated cost is:

1) $147,000 2) $56,000 3) $49,000 4) $112,000 5) NOT

answer 2

6. The point \((x, -1)\) is 13 units from \((3, 4)\). Find the sum of all possible values of \(x\).

7. True or False: The following sets of points are collinear. (Use the distance formula)

a) \((5, -6)\) \((-7, 9)\) \((0, 0)\)  b) \((0, -3)\) \((3, -1)\) \((-3, -5)\)

answers a) False  b) True

8. Match the correct shaded region with the following sets of numbers.

   a) \(\{(x, y)/ x<0 \text{ and } y>0\}\)  1)
   b) \(\{(x, y)/ x>0 \text{ or } y<0\}\)
   c) \(\{(x, y)/ 0<x<1 \text{ and } 1<y<3\}\)

2) 3) 4) 5) NOT
5. Which of the following define exponential functions?
   a) \( f(x) = 2^{3x} \)   b) \( f(x) = 3 \cdot 2^x \)   c) \( f(x) = 3^{2x+1} \)

answer   a

6. Suppose that the County Engineer reported a fissure in Ferguson Lake Reservoir was allowing water to leak out at such a rate that at the end of any hour the amount of water in the Reservoir is .9 of what it was at the beginning of the hour.
   a) If the Reservoir contained 40,000,000,000 gallons of water at noon, find a formula for the amount of water in the Reservoir \( t \) hours after noon.
   b) How much water will be in the Reservoir at 4 p.m.?

answers   a) \( A = 4(10)^{10}(.9)^t \)   b) 2.6244 \( \times 10^{10} \)

7. Sketch the graph of
   \( \{(x,y)/ 0 < x < 1 \text{ or } 1 < y \leq 3\} \)

8. Sketch the graph of
   \( y = \lfloor x + \lfloor x \rfloor \rfloor \) for \( x \) \((-2,3]\)

9. \( y = f(x) \) and \( y \) varies directly as \( x \). Find \( k \) such that
   \[
   \frac{f(x_1)}{f(x_2)} = k \frac{x_1}{x_2}
   \]

10. Show that if \( y \) varies directly as \( x \), then \( x \) must vary directly as \( y \). Replace the word directly with indirectly in the preceding statement.
Use the tables on pages 432-5 and interpolate if necessary.

1. Find a member of the solution set for the following equation
   \[ \sin t = \frac{3}{4} \]

   answer: .848

2. Find a value for \( t \) such that
   \[ \cos t = \frac{3}{5} \]

3. If \( \csc t = 1 \), then \( t \) could be equal to
   a) 1    b) \( \pi \)    c) \( \pi/2 \)    d) 0    e) NOT

4. Dr. Lee said that for small values of \( x \), \( \sin x \) is (approximately) equal to \( x \). Using the tables and rounding values to hundredths, what is the greatest value of \( x \) for which Dr. Lee's statement is true?
5. Two of our OSU Lima aerospace enthusiasts were on the athletic field behind the Student Activity Building flying model airplanes. They both had the same length guide line attached to the planes. The angle of inclination of one of the planes' guide line was $32^\circ$ and that of the other was $39^\circ$. If the two planes made one complete revolution of the pilots in the same amount of time, find the ratio of the speed of the faster plane to the speed of the slower.

6. The exhaust fans in the Technical Education Laboratory are connected to a motor by an uncrossed belt running around two pulleys whose radii are 4 inches and 8 inches and whose centers are 24 inches apart. (See illustration below) Determine the length of the belt. b) How long is the belt if it is crossed once?

answers  

a) 85.4 inches  
b) 89.6 inches
2. 'Usual' method of homework assignments is that method of presenting homework assignments in which at the beginning of the course an assignment sheet listing the following information is given to each student:
   a) sections of the text to be covered along with dates and pages of the text corresponding to individual sections
   b) homework problems by page, number, and section
   c) dates of reviews and midterms
   d) administrative information
   This treatment and those receiving it will be designated as "C" and "the C-group" respectively.

3. Criterion measures: are most of the instruments used in gathering information during this experiment. They are:
   a) Study Habits Questionnaire: a questionnaire designed by the experimenter to try to ascertain attitudes toward homework in mathematics and opinions and perceptions of students' study habits in mathematics. The instrument has a reliability of 0.837 for this study.
   b) Achievement test: a subtest of a previously used final examination. The test has twenty-two items chosen to cover the content of the course. The test has Kuder-Richardson Form 20 and 21 reliability coefficients of 0.644 and 0.538.
c) Examinations: there were three midterms and a final examination given in the course.

d) Shatkin Attitude Test: a standardized mathematics attitude questionnaire with reported reliability of 0.972.

e) Homework opinionnaire: an experimenter-designed opinionnaire to test feeling or opinions about the experiment.

4. Study habits in mathematics: methods of and opinions about doing assignments and preparing for examinations asked about in the Study Habits Questionnaire.

5. Feeling about the importance of homework in mathematics: the position in which the subjects rank homework in comparison to lecture and reading the text in evaluating the contributions of each aspect to their understanding of the mathematics in the Math 150 course.

6. Attitude towards mathematics: the score obtained on the Shatkin Attitude Test. Higher scores denote a more positive attitude.

7. Achievement in mathematics: content achievement as measured in two separate ways.

a) $A_c$ is the content achievement as measured by the Achievement Test.

b) $A_t$ is the total standardized points (T-scores) accumulated on the three midterms and the final
examination of the course.

8. Subjects or students: those students enrolled in the four daytime sections of Mathematics 150 at the Lima Campus of The Ohio State University during the Autumn quarter of 1971.

Objective

The objective of this study is to determine if the personalized method or the "usual" method of assigning homework problems will affect significantly the students' ranking of importance of homework in mathematics, achievement in mathematics, attitude towards mathematics, and perceptions of study habits in mathematics.

Hypotheses

The following null hypotheses are tested in this study:

\( H^1_0: \) There is no significant difference between the E and the C groups, total and by individual instructors, with respect to ranking the importance of homework.

\( H^2_0: \) There is no significant difference between the E and the C groups, total and by individual instructors, with respect to change in scores on the attitude test.

\( H^3_0: \) There is no significant difference between the E and the C groups, total and by individual instructors, with respect to gain score on the achievement test.
There is no significant difference between the E and the C groups, total and by individual instructor, with respect to total achievement.

Observations

In addition to the above hypotheses, findings and observations will be included to describe information which is not subject to a rigid statistical analysis. These observations will include perceptions of the students' study habits, comments of the instructors and students on the treatments, and results of the homework opinionnaire.

The remaining chapters of this dissertation will be concerned with the review of the literature, the effects of the pilot study on this study, a detailed description of the study, an analysis and interpretation of the data, and conclusions, limitations, and recommendations.
CHAPTER II
REVIEW OF RELATED LITERATURE

Many articles have been written on the subject of homework. Of the articles published on the subject of homework in mathematics, most have been based solely on the opinions of various authors; these opinions differ greatly. This chapter will present a review of the literature in three sections: the first will consist of statements of opinions about homework from various authors; the second will contain various appeals for needed research; the third will review studies on homework.

The third section is most relevant to this study because it will show that while earlier studies involving homework were concerned primarily with quantities of homework, some of the more recent studies (Laing (35) and Peterson (51)) are different in that the experiments controlled types of assignments not just quantity. This experiment is also concerned with type - a personalized type of homework assignment.

STATEMENTS ON THE SELECTION, USE, AND RESULTS OF THE USE OF HOMEWORK PROBLEMS

Swenson, Cost, and Greene (65), referring to research before 1950, stated that most of the research
has been unfavorable to homework but cautioned that it should be remembered that "homework" in a typical study was of a rather routine nature - arithmetic examples to be completed, spellings to be memorized, or other drill-type materials.

Epps (26) said that at the present time (1966) we have what has been called a "cobweb theory" of homework. Current practices range from no homework, even for secondary-school students, to a substantial load for pupils in the early elementary grades. Assignments vary from memorization and mechanical exercises to creative projects designed to interest the pupils in the learning process. Romberg and DeVault (32,100) referring to instruction, said that planning is that part of decision making which is concerned with content, sequence, and the selection of activities that is left to the teacher prior to and during the act of teaching; teaching is the face-to-face confrontation of teachers and pupils and is held to be the most important of the instructional tasks; and selection of assignments is an important part of planning, for here the teacher assists the learner in the next cycle of his mathematics inquiry. Jacobs (30), suggesting some characteristics of a modern program of homework, said that the teacher should plan for and with the children concerning their independent work instead of assigning uniform study tasks and then should find
appropriate times and ways to use the results of children's independent homework. Hillman (24), in giving the merits of the spiral technique in homework assignments, said that homework assignments are meant to supplement instruction that occurs in class and therefore the teacher must make a careful selection of each assignment. He concluded with,

By carefully selecting homework exercises that did relate to current class discussions, we were able to complete efficiently current class problems that used the familiar homework problems in a more sophisticated way. (24,250)

Epps (26) stated that even more important than recognizing the need for different amounts of homework for different students is the need to discover how to vary the type of homework assigned to students of varying abilities, interests, and cultural opportunities. Savage (58) wrote that two schools of thought exist which continue the ongoing argument about homework. He said that there are those who consider homework sacred and an essential part of the whole educational process and that these people argue that homework helps build character and self-discipline, that it teaches pupils organizational skills, instills responsibility, and brings parents closer to school. He said that some teachers claim that they could not cover all the requirements of the curriculum without homework and that children insist that homework helps them do better on exams. He further stated that a vocal minority
of teachers, parents, and children disagree, oppose homework, and contend that the school day is long enough and that children need after-school time to relax and to pursue worthwhile out-of-school interests. Savage said that these opponents of homework are quick to point to the convincing argument that homework has never really been proven to help children meet a greater degree of scholastic success or achievement. He said,

> With the increasing demands on education at all levels, the amount of homework being assigned in the elementary school is increasing. Homework is here, and it looks like it's here to stay, at least for a while. Administrators, teachers, parents, and children favor homework. Since it is a part of our educational structure, it must be a directed and constructive teaching-learning tool. (58,4)

Maertens (42) wrote that a substantial part of the elementary student's day is commonly devoted to the preparation of home-study assignments and that many classroom teachers assume that it is their responsibility to assign pupils sufficient work to be completed at home to insure academic success.

Epps (26) partially explained the current emphasis on homework when she stated,

> The launching of the first Russian Sputnik in 1957 sparked a change in a 50-year trend toward less homework. Principals have reported that the biggest change in the years immediately following Sputnik was a movement toward greater emphasis on subject matter. And homework was conceived as a means for attaining academic excellence. (26,3)
Savage (58) and Hillman (24) agreed that a homework policy is essential. The homework should encourage the children to carry on independent work in the home environment and since homework problems are review problems, students should be told that they can discern from the assignments whether they are falling behind. Savage (58) said that when teachers, parents, and children understand their roles and duties regarding homework and when homework is designed to achieve sound educational goals, then homework will lend another positive dimension to the total education of children. He concluded by saying,

Homework shouldn't be a problem. It is designed to be a constructive tool in the teaching-learning process, not to cause problems. Properly handled, homework can be such an aid to learning. (58, 2)

APPEALS FOR RESEARCH

In most of the articles, the authors made appeals for research to be done. Some of the appeals were quite general while others were specifically directed toward some aspect of homework in mathematics.

Riedesel (55) said that research concerned with homework in mathematics at the elementary level has not indicated that achievement or attitude is improved by the use of homework in mathematics but that surveys indicate that parents feel that mathematics homework is of great importance. He then asked and answered the following
question when he wrote,

What should the teacher do? Two suggestions can be gleaned from research. There is some indication that homework aids in immediate increase in computational skill. Therefore, it is suggested that homework assignments involving games, crossword puzzles, and other recreational computational activities be developed in which parent and child cooperatively work on the development of mathematical ideas. These homework assignments can take the form of laboratory activities, puzzles, and experiments. (55, 178)

Mulry (47) stated that several investigations reveal that homework can be most helpful, for some children, at some grade levels and in some subjects, but that the relation of homework to personal and school success is inconclusive and that a fair analysis of the value of homework cannot be made until further evidence is presented. Maertens (42) wrote that attempts of school faculties to develop a sound, defensible homework policy have proved frustrating due to the lack of research at the elementary level. He said that research examining the effects of homework within the separate disciplines would aid in the planning of the curriculum and that the study of homework requirements appropriate to the subject and grade level is needed to avoid fragmentation of the home study program, possible frustration of students, or excessive demand upon their leisure time. He concluded by saying,

The education profession should carefully study the question of homework and its potential contribution to a child's learning. (42, 389)
Strang (64) said that although many opinions exist on the effects of homework on scholastic success, there has been little research on the subject. Savage (58) stated that homework is an endless source of controversy in education and it is like the weather in that everyone talks about it but few do anything about it. He said that lack of experimental research is one of the chief reasons why homework remains such a hotly debated and thorny issue and that the studies which have been done have been too narrow or inconclusive to warrant justification for retaining or abandoning homework. He stated,

Most of the articles and other reports are nonexperimental, and limitations in such factors as adequacy of design, replicability, and scope prevent any sweeping conclusions... In spite of the paucity and inconclusiveness of the research about homework, the practice of assigning it is firmly entrenched in our schools. Homework remains a question, but the question is not, 'To give or not to give?' Rather, the question seems to be, 'What kind to give and why?' (58,1)

Mulry (47) said that although many articles have been written about homework or home study, most of them merely express a subjective viewpoint, and, therefore, there is little conclusive evidence available concerning the positive or negative effect of home study, either the regular assigned homework or the voluntary assignments. She said that of the few experimental studies on the problem of homework that have been reported, many are limited in scope and quality; most of these studies are
inadequate in design and do not involve carefully controlled and well-planned experiments in which the range of factors which influence learning are explored. She stated that since the studies are limited to a sporadic range of grades, to certain subjects, and to short periods of time, results are inconclusive; that of those studies whose research designs are well constructed, many are misinterpreted and used to support preconceived notions about the benefits or harmful effects of homework; and that the conclusions of these studies, usually unfavorable to homework, are often cited rather than the actual findings of the researchers. She said that because of these factors, it is difficult to assess the value of homework in definitive terms as supported by adequate research findings and that, in general, research indicates that greater study is needed before homework as an educational tool can be fully evaluated. Mulry stated that a number of studies indicate that little or no gain in academic achievement results from homework, but the conclusions of several of these studies are contradictory to the data presented and that other studies indicate that when some study is appropriate to the students involved and when it is carefully explained and meaningful, school achievement is favorably affected. She concludes by saying that she hopes that the very lack of conclusive evidence will stimulate the early development of sound research on homework and that it is high time for
opinions to be replaced by facts.

Koch (34) said that parents disagree in their opinions about homework for elementary school pupils and so do teachers and that research does not settle the problem. He referred to the "cobweb theory" in homework in that the opinions on homework vary so much and several philosophies and practices are found to exist. He said that not only is the quantity of research at a minimum, but it appears that the quality of the research leaves something to be desired. He referred to a survey by Goldstein (21) in which most of the available studies were found to be outdated and inadequate because of poor design and/or fragmentary data. He said that in pursuing the topic of homework in arithmetic he found little direction from the literature other than the expressed need for research in the area. Epps (26), in giving a brief history of homework in mathematics, said that although homework is one of the most widely used teaching techniques, it is also one of the most controversial. She stated that in the last five years (1961-1966) more than seventy-five articles had been published on the subject of homework and that most of these articles reported the differing experiences and opinions of administrators, teachers, and parents. Epps said that many of them agreed that a "common sense" approach to homework is needed. She stated that the research that has been done does not lead to any
definitive conclusions and that the very few experimental studies that have been performed have mostly been poorly designed and limited in scope. She summarized the findings of experimental studies by saying,

The majority of the research on homework was done in the 1930's and concerned primarily the question of homework versus no homework. There is apparently no research on the effects of homework in grades 1-4. Also, no research has been reported that provides answers to such questions as what type of homework is most valuable to various types of pupils, and what type of homework is most appropriate to various subjects. Changes in curriculum and teaching methods and materials may call for new types of homework, but so far almost everything that has been published is opinion. Despite the limitations of even the most carefully controlled experiments in this field and the difficulties involved in the types of longitudinal studies required, there is definite need for further research on problems related to homework. (26,4)

Epps concluded by saying that the continued concern of teachers, school officials, pupils, and parents points to the need for further studies to seek answers to such central questions as what kind and how much homework is best for different types of pupils.

REVIEW OF STUDIES ON HOMEWORK

Three articles (65,21,26) have reviewed the research on homework. Swenson, Cost, and Taylor (65), in 1955, summarized the research before 1950 by saying,

While an occasional study...seemed to indicate slight advantages associated with home study, most of the research before the stated date has been unfavorable to homework. (62,20)
They reviewed four reports on the homework problem, published in the 1950's, which they said could be cited as typical of the present situation so far as research was concerned. Descriptions of the four studies follow:

McGill conducted a study to find the effects of homework on (a) achievement in social studies abilities and (b) achievement in economics and American history and government. His results were not statistically significant and he concluded that in the field of high school social studies it made no difference whether homework was assigned or not, either in social studies abilities or achievement test scores. Schiller reported a questionnaire study of junior high school students' reactions to homework was indicated by approximately 43 per cent of the student population of the school (33 per cent of the boys and 50 per cent of the girls). Mathematics homework received the highest response as being helpful (41 per cent), but mathematics homework was cited by only 18 per cent as being the most enjoyable homework. Collins conducted a thorough survey of opinions of teachers, pupils, and parents with regard to homework. The survey used parallel sets of questions for the three groups so that responses could be compared with respect to 1) types of homework assignments, 2) amount of help required by children with these assignments, 3) amount of time spent on them, 4) conditions for home study, 5) attitudes toward homework,
and 6) the value, if any, of assigned homework. She
drew several conclusions from her data and pointed out
that the disagreement of the responses by pupils, parents,
and teachers on various questions indicated a need for
joint study of homework problems. Brimm's study followed
closely the suggestions of Collins. Brimm tells how the
faculty at Teachers College High School of Cedar Falls,
Iowa, worked on the problem of home study. He stated that
while no general agreement was reached a faculty committee
recommended,

Teachers may decide whether they wish to
assign out of class study or not. In general,
assignments should be less time consuming in
junior high school with increasingly more
difficult assignments being made as the pupils
progress through grades 9 to 12. Assignments
need not be made to keep students busy and
should not be made as punishment. (65,22)

Of these four "typical" studies, two were surveys, one
described how faculty, administrators, pupils, and par-
ents worked on the problem of home study, and only one
of the studies tried to determine the effects of home-
work on achievement.

The second article written by Goldstein (21) in
1960 was a comprehensive review of research on home-
work. His purpose was to examine the value of homework
in the light of the pertinent research published during
the thirty years before December, 1958. He said,

For this period the Education Index lists
280 titles on home study. Most of the articles
are anecdotal or polemic and concern length and type of homework assignments. They provide insight into the waxing and waning debate through the decades...Of the 280 titles, only seventeen are actual reports of experimental research on the homework problem...Not only do the experimental designs in investigations leave much room for improvement, but even the well-designed studies...have been widely misinterpreted to support preconceived notions about the uselessness or harmful effects of homework. (21,213)

Epps (26) agreed with Goldstein that the Di Napoli study, conducted in 1935, has been the most extensive study of homework in the elementary grades to date. Di Napoli contrasted compulsory-homework and voluntary-homework classes. In the voluntary-homework classes, no work or study was required at home. The teachers of these classes arranged their work so that study periods could be assigned during school hours. Voluntary homework was not discouraged; only regular, compulsory homework was abolished. In the compulsory-homework classes regular daily assignments were given. All the subjects were given the same pre-test and post-test. The gain on test scores favored the compulsory-homework group in eight of the nine subjects at the fifth grade level. The total average gain was significant at the .05 level in favor of the compulsory-homework group. For the seventh grade, the gains favored the compulsory group in some subjects and the voluntary group in others. The over-all gain for seventh grade students favored the voluntary group, but only very slightly. Di Napoli concluded that com-
pulsory homework in the fifth grade, for both male and female, favors achievement at the .05 level of significance while in the seventh grade, voluntary homework favors achievement very slightly. Contrary to his findings, Di Napoli reported in his recommendations,

This experiment was conducted to test the validity of the single claim that compulsory homework results in improved academic achievement...The results of this experiment reveal the fallacy of the claim...then on the basis of the results of this study, the writer recommends the abolition of compulsory homework in favor of voluntary homework. (21,214)

Goldstein said that it seemed as if two different people must have written the findings and recommendations and that, unfortunately, Di Napoli's recommendations rather than his actual findings were cited repeatedly in subsequent discussions of the homework problem.

Crawford and Carmichael conducted a longitudinal study in which they found that students (grades 5 through 8) did better when they had compulsory homework as compared with when they had no homework (the school abolished compulsory homework). Carmichael reported,

As the children entered El Segundo High School in the years following abolition of compulsory homework, there was a marked deterioration in their achievement in high-school subjects, compared with the experience of former years or compared with classmates who had attended elementary schools where compulsory homework remained in force. (21,215)

Crawford and Carmichael reported that something caused a significant drop in the high-school marks of the
graduates of El Segundo Grammar School after home study in the grammar school was abolished. The conclusions of this study, like those of Di Napoli, bore little relationship to the actual findings, and these conclusions, as were Di Napoli's were widely cited as evidence against having compulsory homework.

Vincent conducted a study in which he abolished homework for twenty weeks in selected subjects in grades 5 and 6. His data showed that the homework group was superior in arithmetic but not in geography or English. He concluded that it does not pay to require homework from all children in grades five and six. Cooke and King performed a questionable experiment of homework versus supervised study and argued that since gains were made in both groups, home study is of no value. Teahan tested homework and non-homework groups by matched pairs and concluded that homework is of no value in promoting achievement in arithmetic. Steiner examined a single seventh-grade class in which half of the pupils had compulsory homework in arithmetic but not in English. For the other half of the pupils the assignments were reversed. The homework group showed clear gains in arithmetic over the no-homework group. Montgomery conducted an experiment similar to that of Steiner's only at mid-year he crossed the groups over from arithmetic homework to English homework and vice versa. He found
a slight advantage for homework in arithmetic for all students (grades 7 through 9), and for the ninth grade and the groups with highest intelligence quotients he found "a decided result in favor of home study" in arithmetic, but in favor of no homework in English. Foran and Weber also conducted an experiment in which a cross-over pattern was used. No homework was given in any subject but arithmetic and then only for one of the two terms. One group had homework in arithmetic only the first term, and the other group had homework in arithmetic only the second term. Both groups had greater achievement gains in problem-solving with homework than without; in computation the outcome was less clear but showed the same tendency. These authors also concluded that homework has no effect on achievement, which was contrary to their findings. Here again, the conclusions instead of the findings were cited by subsequent reviewers.

Anderson studied achievement gains for eighth-grade classes in English, social studies, and mathematics. A comparison was made between classes that did and did not have regular homework assignments. The group with regular homework assignments showed higher achievement gains in all three subjects.

Goldstein concluded from his review that experimental findings do not warrant statements that homework contributes little or nothing to immediate academic achievement
but that, on the contrary, homework definitely favors higher academic achievement in the upper elementary and secondary grades for some pupils in some subjects.

The third review, written by Epps (26) in 1966, gave an overview of the various trends that homework has gone through since approximately 1920. She reviewed only five studies and only one of these, the one by Hines, was different from the studies reviewed by Goldstein.

Hines (26) attempted to answer the question of the value of out-of-class study for achievement in plane geometry. He started with nineteen matched pairs of students. The pairing was based upon chronological age, intelligence quotients, and point averages for two semesters of beginning algebra. The two participating teachers, Hines and a colleague, took turns drawing from each pair to form their classes. Initial testing indicated a high level and almost exact retention of algebra over the summer by the two groups and very little knowledge of plane geometry. The teachers coordinated their work to spend the same number of days on each topic presented from their common textbook. The control group, taught by Hines, was given out-of-class assignments. Both classes had some supervision in class study. Hines conducted the study over the entire school year. He found that every one of the seventeen comparisons favored the homework group; nine were significant at or beyond the
five per cent level. His conclusions were:

1. Out-of-class study, usually written work, increases achievement in plane geometry.

2. The differences in achievement tend to be cumulative.

3. Differences tended to be slightly greater on cumulative review tests than on the unit tests covering recent material.

4. If a traditional grading system were used - A, B, C, D, E - and if students were graded only on the tests, home study would increase the grade of the average student by one letter.

There were several limitations to this study. He used only sixteen of the nineteen pairs for his conclusions. The number of subjects is quite small. Hines told the students about the experiment at the beginning of the year. He admitted that differences found might be attributed to differences in skill or zeal on the part of the two teachers involved. And finally he made no attempt to determine if the control students worked the assignments or if the experimental students did not work assignments out of class.

Koch (34) investigated whether or not daily practice at home, in addition to the regular lessons in class, would increase achievement in arithmetic for sixth grade students. He also examined whether long (30 minutes) daily assignments or short (15 minutes) ones influenced achievement in arithmetic more. Koch used three classes: one received the long daily assignments, one received the
short daily assignments, and one class received no homework. He found that he did not have significant evidence to say flatly that homework increases achievement in arithmetic, although some of his data seemed to favor this conclusion. He also concluded that it does not seem to matter how long the homework assignments are.

Bassler (2) investigated the comparative effects of two distinct types of exercises upon achievement in teaching mathematical concepts to prospective elementary school teachers. The two types of exercises were designated as theoretical (purely mathematical setting) and applied (physical world setting). The criteria for measurement consisted of a post-test and a retention test administrated several weeks after the post-test. He concluded that the two methods were equally effective and that the role which various types of exercises have in the learning of mathematics is not as great as had previously been believed.

Whelan (69) investigated the effect of systematic homework assignments in English and arithmetic on the achievement of fourth grade pupils. He did not find any significant differences between the groups as a whole or when they were classified as to sex or ability.

Ten Brinke (66) investigated the effect of homework on achievement in mathematics in grades 7 and 8. He contrasted homework and supervised study as his treatments. The class designated as the homework class received
daily assignments that were corrected and collected at the beginning of the succeeding period while the class designated as the supervision class received shortened daily assignments to be done in the last half of each class period. He did not find significantly superior achievement for the homework group compared to the supervised study group, but a majority of the means for the homework classes were numerically larger than those for the supervised study classes. He found indications that homework was more productive for upper-ability students while supervised study was more productive for low-ability students.

Zastrow (75) examined the effect that repetition (in the form of solving homework problems) had upon the learning process of students in college statistics and calculus classes when the subject matter was meaningfully presented. Zastrow devised a new "meaningful" method of instruction and obtained data for the experiment by having the calculus students alternate doing homework and not doing homework and having the statistics students do homework on a random basis. To insure adherence to his procedure he used one-question quizzes in class when time permitted. Half of the questions on each of the three parts of his examinations were chosen from topics for which homework had been assigned and half from topics for which no homework had been assigned. He found no significant differences in results obtained with or with-
out homework problems under simple recall and relatively few in understanding of concepts. The calculus classes consistently yielded significant differences favoring homework for acquiring skill in problem solving, but no differences were obtained in the statistics class.

Mason (43) examined whether required homework results in greater achievement by students in a course in college algebra. He found that there were no significant differences in results obtained by requiring homework or not requiring homework when averaged over all the teachers in the study, but he found that there was a 99.5 per cent significance level of teacher by method interaction and concluded that each teacher should determine which of the two methods to use for him to be more effective.

Bradley (3) investigated the comparative effectiveness of assigning homework to fifth graders by the individualized method, the homework designed specifically to meet the needs and abilities of individual pupils, and the blanket-type method - homework directed to the class as a whole with each student receiving the identical assignment. He found a significant difference of mean gain in achievement favoring the individualized method but differences on an interest measure in mathematics were not found to be significant.

Maertens (42) investigated the effect of arithmetic
homework upon the arithmetic achievement and attitude of 3rd grade students. He used self-contained classrooms in which the students were given teacher-prepared homework, experimenter-prepared homework, and no homework respectively for the three-month periods of the school year. He did not find any significant effects of arithmetic homework upon arithmetic achievement or attitude, but he found the effect of arithmetic homework upon the attitudes of the students toward spelling was significant at the .05 level.

Peterson (51) examined the "Effect of Exploratory Homework Exercises Upon Achievement in Eighth Grade Mathematics." He used three groups: an experimental group, a placebo group, and a control group. He used the semi-oblique (advanced organizer base) method (assigning exploratory homework exercises on a topic the three days preceding the teaching of the topic). He found that students' achievement, retention, and transfer of eighth grade mathematical concepts seemed to be improved when the students were assigned and attempted exploratory homework exercises using the semi-oblique method.

Laing (35) compared the effects of two assignment schedules for distributing topics on homework assignments of middle-track eighth grade mathematics classes. Homework assignments for the two treatments had identical problem content. One treatment massed problems pertaining
to a given topic on one concentrated assignment while the other treatment distributed the problems over a number of assignments. The two groups were compared on initial learning, measured by examinations over number concepts, and retention measures obtained by administering an instrument after three weeks of interpolated activity. He found no significant differences between the two treatment groups on total test scores, but differences between adjusted means consistently favored the distributed treatment group on each of the initial learning and retention measures. He found a possible interaction between treatment and achievement component. Adjusted means on computational skills, comprehension, applications, and his component subtests favored the distributed treatment group.

Milles (45) developed homework questions that called for mathematical verbalization. He used three groups for his study. The control group C received a specified part of the usual assignment; the verbal group V handed in responses to a disjoint set of questions identified as seeking mathematical verbalization. He controlled content and format for the groups by assigning the same non-verbal problems to all three groups. Milles found no significant differences with respect to achievement by sections. However, when the student was used as the basic unit of analysis, the C group did significantly
better than the V group (.05 level) on non-verbal achievement.

The reviews and studies of this chapter were presented in chronological order to show the trends of research on homework in mathematics. The earlier studies (before 1955) were primarily concerned with determining whether homework was better than no homework. From 1955 to 1965, while many of the studies still were concerned with homework versus no homework, some studies investigated how much homework to give and the effects of homework upon achievement and attitude in mathematics. Most recently the studies have sought answers to specific cases of the general question, "What kind of homework is best for students in different subjects and at different grade levels."

No single study from the review can be declared as most important to this study. What seems to be most relevant is the noticeable lack of research on homework, especially in mathematics at the college level, and the nearly unanimous appeals of the reviewers for research on homework at all levels. Hines' and Crawford and Carmichaels' interpretations seem to be most important for studies on homework in general. They indicated that the benefits of homework may not be immediate but tend to be cummulative.

Chapter III will present the effects of the pilot study upon the current experiment.
CHAPTER III
EFFECTS OF THE PILOT STUDY

A pilot study to this experiment was conducted during the Spring Quarter 1969 when information concerning prospective elementary teachers' viewpoints on the importance of homework in mathematics, the effects of different types of homework assignments on the prospective teachers' attitudes towards mathematics and their achievement in mathematics, and perceptions of and opinions about study habits in mathematics were gathered. This chapter will give a brief description of the pilot study and the effects of that study on the current experiment.

The population of the study was 253 prospective elementary teachers enrolled in Mathematics 105, a required course for almost all elementary education majors at The Ohio State University. Two daily sections of the course were offered. On Mondays, Wednesdays, and Fridays, large group lectures were given to the two sections of students by the same instructor; one section met at twelve o'clock noon and the other at 2 p.m. On Tuesdays and Thursdays, small group recitation meetings were conducted by the five assistants to the instructor. Each
assistant taught one noon section and one two o'clock section. No new material was discussed in the recitation classes. The recitation classes were designed and used to discuss the previous lectures and to answer questions about the homework problems. The independent variables in this study were three methods of distributing homework and the formats in which the problems were presented. The dependent variables were the students' attitudes, achievement, and perception of study habits in mathematics.

The five two o'clock recitation sections were designated as the C (control) group and were assigned homework problems directly from the text via a course syllabus. There were 107 students in the control group. Two of the five noon recitation sections were designated as the E₁ (Experimental I) group and were assigned problems similar to those from the text which had been assigned to the C group. These assignments were constructed by the experimenter and distributed to the students on mimeographed sheets during the recitation sections. On Tuesdays, assignments for the Wednesday lectures were distributed and on Thursdays, assignments for Friday and Monday lectures were distributed. There were fifty-eight students in the E₁ group. The other three noon recitation sections consisting of eighty-eight students were designated as the E₂ (Experimental II) group and were assigned
the same problems as the $E_1$ group but in a different format. The assignments for the $E_2$ group were arranged in the form of a test in that the questions were multiple choice, matching, true or false, and short answer or computational problems. In addition, the problems for the $E_2$ group were weighted so that each assignment would have a numerical value of one hundred points. (See Appendix for examples of the $E_1$ and $E_2$ assignments.) The problems for the $E_2$ group were distributed in the same manner as the problems for the $E_1$ group.

The objectives of the study were:

1) to determine by a questionnaire
   a) which of the $E_1$, $E_2$, or C methods of assigning homework problems was associated with the highest attitude toward the importance of homework in mathematics.
   b) correlations between specific study habits in and opinions about homework in mathematics.

2. to determine by means of an achievement test
   a) which of the three methods of assigning homework was associated with the highest mathematical achievement.
   b) which of the $E_1$ or $E_2$ methods correlated more highly with gains in mathematical achievement (a pretest-posttest method was used).
3) to determine by means of a standardized attitude test
   a) which of the three methods of assigning homework
      exercises was associated with the students' having
      most positive attitudes toward mathematics.
   b) whether the $E_1$ or $E_2$ group had the greater change
      in attitude towards mathematics (a pretest - post-
      test method was used).

4) to compare opinions about homework and study habits
   in mathematics of the Upper-Lower 27 per cent of the
   students in attitude scores and achievement scores by in-
   treatment and cross-treatment methods.

5) to determine which of the three groups of students
   could best predict their final grades in the course be-
   fore taking the last midterm or final examination.

6) to report incidental information obtained from the
   study which was not subject to a rigorous statistical
   analysis.

   The Mathematics Study Habits Questionnaire
   (Appendix C; Spearman-Brown reliability 0.728) and the
   assignments for the $E_1$ and $E_2$ groups were experimenter-
   designed. The attitude test was the Shatkin Attitude
   Test, a standardized instrument with reported reliability
   of 0.972 (60). The three midterms, final examination,
   and the achievement test were all constructed by the
   course instructor, Charles McNerney. The achievement test,
   which was used as a pretest and posttest had reliability of
0.742 and 0.670 determined by Kuder-Richardson 20 and 21 tests respectively. The experimenter also designed and used two data gathering questionnaires (Appendix J) and had the course assistants keep records of their own thoughts and comments of their students pertaining to the treatments and/or the course. The experimenter provided the students with a calendar of the quarter and asked the students to record daily the amount and the distribution of the time spent in studying for the course.

One-way analysis of variance was used to test the hypotheses corresponding to the objectives. The students' perceptions of study habits were submitted to a correlational analysis. The results of the study were interpreted and used in the design of the current experiment as follows:

Objective 1 a) was examined and the results showed that the $E_2$ group ranked homework as a more important contributor to the understanding of mathematics than either of the other two groups; the $C$ group ranked it the lowest. Analysis of the homework variable showed a significant difference between the $E_1$ and $C$ groups at the 0.05 level and between the $E_2$ and $C$ groups at the 0.01 level. Objective 2 was examined and the results showed that the $E_2$ group had the highest achievement score on the test designed to measure achievement in the course, but the $C$ group had the highest scores measured by the
total standard scores on the three midterms and final examination. Analysis of the achievement variable revealed significance at the 0.05 level in favor of the $E_2$ group over the $E_1$ group on the specially designed achievement test on the posttest alone, but no significant difference at or below the 0.20 level was found when gain scores were examined; however, the gain scores did favor the $E_2$ group. Objective 3 was examined and no significant differences were found with respect to the attitude variable. The $E_2$ group had the highest (most positive) attitude toward mathematics; however, the results of the pilot study seemed to indicate a pattern. There appeared to be a more positive correlation between the $E_2$ and $E_1$ groups than between either of them and the $C$ group with respect to the variables of homework and attitude. The author interpreted these findings along with comments of the instructor, course assistants, and students and came to the following conclusion. The students appeared to react more to the idea that something different was being done for them in the course than to the degree to which it was being done; that is to say, the students in the $E_1$ and $E_2$ groups were reacting to a kind of personal treatment involving homework as contrasted to the usual treatment of homework given to the $C$ group. The differences in the reactions between the $E_1$ and $E_2$
groups were not as great as the author had anticipated. These conclusions led the author to consider only two treatments in the current experiment, a personalized treatment and a control treatment.

The remaining pages of this chapter contain the analyses of the experimenter-designed questionnaires which were used in the pilot study and the effects of those analyses on the instrumentation for the current study.

Section I of the study habits questionnaire asked the students to rank the recitation, text, homework, and lecture variables by importance in contributing to the understanding of mathematics. Each of the three groups ranked the variables in the same order, most important to least important: lecture, homework, recitation, and text. The homework variable was discussed earlier in this chapter. For the current study, because all of the classes were self-contained, the recitation variable was deleted.

Section II of the study habits questionnaire contained six statements pertaining to study habits; the students were asked to select one of the three phrases to complete the statements of Section II.

Section II of the study habits questionnaire is presented here for reference to Table I, which gives the number of responses to each answer to the statements. The
answers are given, by groups, for the pretest and the posttest.

II. Place the letter of the most appropriate answer in the answer column to the right.

1. Excluding test scores, I judge my standing in class on
   a) how well I do on my homework assignments
   b) how well I understand my readings
   c) how well I follow the lectures

2. When I study, I
   a) have the radio, record player, or television on
   b) require complete silence
   c) carry on a conversation with a classmate

3. When doing homework, I rely mainly on what I learned
   a) in lecture
   b) by reading the text
   c) both a and b

4. I study
   a) by myself
   b) with only one other student
   c) with more than one other student

5. I start my homework assignments
   a) as soon as possible after lectures
   b) the latest possible time before recitation
   c) other

6. I do my homework
   a) all at one time
   b) with infrequent interruptions
   c) without a set pattern
### TABLE I
RESPONSES TO SECTION II OF MATHEMATICAL STUDY HABITS QUESTIONNAIRE

(POST-QUESTIONNAIRE RESPONSES ARE IN PARENTHESIS)

<table>
<thead>
<tr>
<th></th>
<th>$E_1$</th>
<th>$E_2$</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>31 (35)</td>
<td>35 (46)</td>
<td>33 (32)</td>
</tr>
<tr>
<td>b</td>
<td>0 (1)</td>
<td>1 (2)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>c</td>
<td>27 (22)</td>
<td>52 (40)</td>
<td>70 (70)</td>
</tr>
<tr>
<td>a</td>
<td>8 (8)</td>
<td>16 (18)</td>
<td>22 (22)</td>
</tr>
<tr>
<td>b</td>
<td>49 (49)</td>
<td>67 (67)</td>
<td>79 (80)</td>
</tr>
<tr>
<td>c</td>
<td>1 (1)</td>
<td>5 (3)</td>
<td>6 (5)</td>
</tr>
<tr>
<td>a</td>
<td>36 (45)</td>
<td>58 (58)</td>
<td>64 (59)</td>
</tr>
<tr>
<td>b</td>
<td>0 (0)</td>
<td>0 (1)</td>
<td>3 (1)</td>
</tr>
<tr>
<td>c</td>
<td>22 (13)</td>
<td>30 (29)</td>
<td>40 (47)</td>
</tr>
<tr>
<td>a</td>
<td>50 (47)</td>
<td>76 (73)</td>
<td>94 (94)</td>
</tr>
<tr>
<td>b</td>
<td>4 (7)</td>
<td>11 (15)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>c</td>
<td>4 (4)</td>
<td>1 (0)</td>
<td>4 (4)</td>
</tr>
<tr>
<td>a</td>
<td>28 (25)</td>
<td>38 (39)</td>
<td>31 (40)</td>
</tr>
<tr>
<td>b</td>
<td>2 (3)</td>
<td>5 (10)</td>
<td>14 (11)</td>
</tr>
<tr>
<td>c</td>
<td>28 (30)</td>
<td>45 (39)</td>
<td>62 (56)</td>
</tr>
<tr>
<td>a</td>
<td>27 (27)</td>
<td>24 (30)</td>
<td>45 (43)</td>
</tr>
<tr>
<td>b</td>
<td>10 (10)</td>
<td>21 (14)</td>
<td>18 (16)</td>
</tr>
<tr>
<td>c</td>
<td>21 (21)</td>
<td>43 (44)</td>
<td>44 (48)</td>
</tr>
</tbody>
</table>
Examination of Table 1 shows that the $E_2$ group had a shift of 12.5 per cent of its students from judging their standing in class from how well they followed the lectures to how well they did on their homework assignments. The 12.5 per cent increase towards homework for the $E_2$ group compares with a 6.9 per cent increase in the $E_1$ group and a 0.9 per cent decrease in the C group. This information supports the significant difference found in ranking homework as a contributor to the understanding of mathematics. Discussions with the instructor, course assistants, and some of the students revealed that some of the questions were not clear to the students. Three of the six questions were altered for use in the current experiment. The third response to "When I study, I ________" was changed from "carry on a conversation with a classmate" to "am in a room where others sometimes distract me." This change was necessitated because the interpretation of carrying on a conversation while studying was not clear and because the Lima Campus is a commuter campus and the students do not have as convenient opportunities to study together as do students on the Columbus Campus. The third response to "When doing homework, I rely mainly on what I learned ________" was changed from "both a and b" to "from previous mathematics courses." The second response to "I start my homework assignments ________" was changed from "the latest possible
time before recitation" to "the latest possible time before the next lecture" since the recitation variable was not present in the current study.

Section III (Appendix C) of the study habits questionnaire was patterned after the attitude test used in the pilot study. The author constructed questions involving homework and study habits pertaining to mathematics and circulated the questions to friends for their critiques and/or additions. The author then wrote each question on a slip of paper, mixed them thoroughly and drew them one at a time from a box; this determined the order of the statements in Section III. Ten of the statements (1-6,8,13,17,21) were positively oriented and the other fifteen were negatively oriented. The responses of the statements were given numerical values as follows: on the positive-oriented statements H-1, S-2, F-3, U-4, A-5 and on the negative-oriented statements H-5, S-4, F-3, U-2, A-1. Therefore, higher numerical values were associated with perceptions of stronger study habits. The posttest means for each of the twenty-five statements were calculated by group. The range of the means was 2.18 to 4.88. The numbers of statements whose means were above 4 or below 2 are listed in order (highest to lowest) with means in parenthesis in Table 2.
TABLE 2
RANKING OF STATEMENTS IN SECTION III OF MATHEMATICS STUDY HABITS QUESTIONNAIRE

<table>
<thead>
<tr>
<th>Rank</th>
<th>$E_1$</th>
<th>$E_2$</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9 (4.88)</td>
<td>9 (4.83)</td>
<td>9 (4.82)</td>
</tr>
<tr>
<td>2</td>
<td>20 (4.84)</td>
<td>5 (4.76)</td>
<td>5 (4.77)</td>
</tr>
<tr>
<td>3</td>
<td>5 (4.81)</td>
<td>20 (4.69)</td>
<td>10 (4.69)</td>
</tr>
<tr>
<td>4</td>
<td>10 (4.78)</td>
<td>10 (4.60)</td>
<td>25 (4.56)</td>
</tr>
<tr>
<td>5</td>
<td>25 (4.64)</td>
<td>25 (4.60)</td>
<td>20 (4.52)</td>
</tr>
<tr>
<td>6</td>
<td>23 (4.62)</td>
<td>1 (4.52)</td>
<td>11 (4.43)</td>
</tr>
<tr>
<td>7</td>
<td>1 (4.48)</td>
<td>6 (4.47)</td>
<td>6 (4.32)</td>
</tr>
<tr>
<td>8</td>
<td>6 (4.47)</td>
<td>11 (4.28)</td>
<td>23 (4.29)</td>
</tr>
<tr>
<td>9</td>
<td>18 (4.38)</td>
<td>23 (4.27)</td>
<td>1 (4.27)</td>
</tr>
<tr>
<td>10</td>
<td>11 (4.21)</td>
<td>24 (4.24)</td>
<td>18 (4.23)</td>
</tr>
<tr>
<td>11</td>
<td>16 (4.17)</td>
<td>18 (4.18)</td>
<td>14 (4.04)</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>14 (4.09)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>16 (4.06)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>3 (2.68)</td>
<td>8 (2.87)</td>
</tr>
<tr>
<td>24</td>
<td>21 (2.72)</td>
<td>21 (2.43)</td>
<td>21,3 (2.73)</td>
</tr>
<tr>
<td>25</td>
<td>12 (2.26)</td>
<td>12 (2.18)</td>
<td>12 (2.44)</td>
</tr>
</tbody>
</table>
Examination of Table 2 reveals that the three groups had approximately the same perceptions of their own study habits as measured by Section III. A summary of their most positive perceptions implies that they checked homework assignments and examinations to find their errors, they copied examples and diagrams from the chalkboard and worked harder than just to receive a passing grade, and they felt that they should take time to do all their homework and they saw relevance in the mathematics they studied in reference to what they planned to do. Their three most negative perceptions were that they felt that carelessness was their biggest downfall in studying mathematics, they felt that their grades in mathematics were not an accurate description of their ability in mathematics, and they did not outline the main points of their notes from lectures and from their readings. The greatest deviations of the means of the three groups on any one perception occurred on statement 8 – "I use my homework assignments as a guide for the amount of studying I should do." The means for this statement were: E₁ (3.64), E₂ (3.56), C (2.87). Many students commented that they had difficulty in answering statement 2 – "Even though I do not like mathematics, I work very hard at it" – because they did indeed like mathematics. The word "do" was replaced with the word "may" for the present study.
In using a split-halves reliability coefficient only an even number of items may be used; therefore, the author added one statement to increase the number of statements in Section III to 26. That statement, numbered 25, is "I use my homework as the primary source for studying for examinations."

Another questionnaire was administered to the students in the pilot study. This questionnaire was given at the end of the course and is presented here for reference.

1. Did you find the homework problems adequate?
   _____Yes  _____No  _____Undecided

2. Did you like the way the homework problems were presented?
   _____Yes  _____No  _____Undecided

3. Do you feel that the way your homework assignments were presented contributed more to your understanding than the 'usual' (assigning directly from the text) method would have?
   _____Yes  _____No  _____Undecided

4. Do you feel that you may treat homework assignments differently from the 'usual' when you begin teaching?
   _____Yes  _____No  _____Undecided

5. Did you grade your homework assignments to obtain an evaluation of your achievement?
   _____Yes  _____No  _____Sometimes

The results of this questionnaire are presented in Table 3 with the number of students (per cents of each
### TABLE 3
RESPONSES TO HOMEWORK QUESTIONNAIRE

<table>
<thead>
<tr>
<th></th>
<th>$E_1$</th>
<th>$E_2$</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes</td>
<td>41 (70.7)</td>
<td>70 (79.5)</td>
<td>63 (58.9)</td>
</tr>
<tr>
<td>No</td>
<td>13 (22.4)</td>
<td>15 (17.0)</td>
<td>34 (31.8)</td>
</tr>
<tr>
<td>Undecided</td>
<td>4 (6.9)</td>
<td>3 (3.4)</td>
<td>10 (9.3)</td>
</tr>
<tr>
<td>Yes</td>
<td>47 (81.0)</td>
<td>64 (72.7)</td>
<td>60 (56.1)</td>
</tr>
<tr>
<td>2. No</td>
<td>6 (10.3)</td>
<td>15 (17.0)</td>
<td>34 (31.8)</td>
</tr>
<tr>
<td>Undecided</td>
<td>5 (8.6)</td>
<td>9 (10.2)</td>
<td>13 (12.1)</td>
</tr>
<tr>
<td>Yes</td>
<td>51 (87.9)</td>
<td>75 (85.2)</td>
<td>80 (74.8)</td>
</tr>
<tr>
<td>3. No</td>
<td>4 (6.9)</td>
<td>7 (8.0)</td>
<td>13 (12.1)</td>
</tr>
<tr>
<td>Undecided</td>
<td>3 (5.2)</td>
<td>6 (6.8)</td>
<td>14 (13.1)</td>
</tr>
<tr>
<td>Yes</td>
<td>36 (62.1)</td>
<td>54 (61.4)</td>
<td>69 (64.5)</td>
</tr>
<tr>
<td>4. No</td>
<td>6 (10.3)</td>
<td>7 (8.0)</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td>Undecided</td>
<td>16 (27.6)</td>
<td>27 (30.7)</td>
<td>35 (32.7)</td>
</tr>
<tr>
<td>Yes</td>
<td>28 (48.3)</td>
<td>18 (20.5)</td>
<td>39 (36.4)</td>
</tr>
<tr>
<td>5. No</td>
<td>22 (37.9)</td>
<td>47 (53.4)</td>
<td>39 (36.4)</td>
</tr>
<tr>
<td>Sometimes</td>
<td>8 (13.8)</td>
<td>23 (26.1)</td>
<td>29 (27.1)</td>
</tr>
</tbody>
</table>
As can be seen from Table 3, 79.5 per cent of the \(E_2\) group thought that the homework problems were adequate compared with 70.7 per cent of the \(E_1\) group and only 58.9 per cent of the \(C\) group; but 81 per cent of the \(E_1\) group liked the way the problems were presented compared with 72.7 per cent of the \(E_2\) group and only 56.1 per cent of the \(C\) group. Students do not necessarily have to like the way the homework is presented to declare it adequate.

Results of responses to question 3 show most of the students felt that the way the homework was presented contributed more to the understanding of mathematics than the 'usual' way would have. The responses of the \(C\) group (74.8 per cent) to this question are believed to be the result of the seven hand-out worksheets and four sample examinations that were given to all students in the course to supplement the text. The author feels that these hand-outs and sample examinations were a contamination of the treatments. In the present study a sample final examination was the only supplemental material distributed to the \(C\) students. The first three questions on this questionnaire were retained in the present study.

Slightly over 60 per cent of the students in each group said they felt that they would treat homework assignments differently from the 'usual' when they begin teaching.

Question 5 - "Did you grade your homework assignments to
obtain an evaluation of your achievement?" - was misinterpreted by the students, perhaps because of the poor choice of the word 'grade'. Of the $E_1$ students 48.3 per cent responded that they graded their homework, compared with 36.4 per cent of the $C$ group and only 20.5 per cent of the $E_2$ group, even though the homework assignments were specially designed to make them easy for the $E_2$ group to grade and to obtain a numerical evaluation. It was conjectured that the $E_2$ group interpreted 'grade' to mean actually determining and recording a numerical score and that the other two groups interpreted 'grade' to mean checking the assignments closely. The last two questions were not retained for the current experiment - question 4 because this group of students were not made up of prospective teachers, and question 5 because the homework assignments in this study did not incorporate the grading aspect.

The course assistants and instructor aided in the pilot study by recording their comments and those of their students with respect to the treatments and/or the course. This method of gaining information was retained in the present study.

This chapter attempted to describe the effects of the pilot study on the current experiment with respect to design and instrumentation. The results of the pilot study indicated to the author that the students reacted
more to the idea that something special was being done for them than to the degree to which it was being done. They seemed to be reacting to a kind of personal treatment involving homework. These conclusions led to the formulation of the personalized treatment used in this study. The comments of the students and instructors involved in the pilot study aided the author in designing the questionnaires for the present study.

A description of the current experiment will be presented in the next chapter.
CHAPTER IV
DESCRIPTION OF THE STUDY

The study described herein was conducted on the Lima Campus of The Ohio State University during the Autumn Quarter, 1971. This experiment was designed to study the effects that changing the format of the usual textbook assigned homework problems to a "personalized" format of homework assignments on daily handouts would have on the attitude toward homework, perceptions of study habits, attitude towards mathematics, and achievement in mathematics.

BACKGROUND AND DESCRIPTION OF THE COURSE

Mathematics 150 is a five quarter-hour course offered at the Lima Campus of The Ohio State University autumn, winter, and spring quarters each year. On the central campus in Columbus, it is offered each quarter. It is designed for students pursuing degrees in mathematics, the physical sciences, architecture, agricultural science, and veterinary medicine. Students in other fields may elect Mathematics 150 to fulfill their mathematics requirements. The Ohio State University Bulletin (p. 294) lists the content of Mathematics 150 as 'Inequalities,
functions, graphs, exponential, logarithmic and trigonometric functions and their graphs, complex numbers, inverse functions.' Each of these topics was included in the course during the experiment. The prerequisite to Mathematics 150 is a grade of D or better in Mathematics 101, a programmed course in basic algebra and functions, or a satisfactory score on The Ohio State University Mathematics Placement Test, or waiver of any prerequisite.

At The Ohio State University one of two mathematics placement examinations is administered to all incoming freshmen students to determine the students' proficiency in mathematics. Whether the student takes Form B or Form D of the placement test is determined by his level of achievement in mathematics as measured by the American College Test. On the basis of the results of the mathematics placement test and quality points from high school mathematics courses, each student is classified at one of five levels. If a student places at Level Five, the lowest level, he must review remedial mathematics through the level of first year algebra before he is permitted to retake the placement examination. A remedial course of this type is offered on the Lima Campus through the Department of Continuing Education but does not carry any university credit. If a student places at Level Four, he is eligible to take Mathematics 101, a prerequisite to Mathematics 150. If the student places at Level Three or
above, he is not required to take any remedial mathematics but is eligible to take Mathematics 150.

The text for the course was Integrated Algebra and Trigonometry With Analytic Geometry, Second Edition, by Fisher and Ziebur. This text has been used for the Mathematics 150 course on all the campuses of The Ohio State University for a number of years.

Course Procedures

Five sections of Mathematics 150 were offered on the Lima Campus, Autumn Quarter, 1971. One of the sections was offered in the evening and had only five students enrolled, all of whom were part-time students taking only this course. They were not included in the study. The other four sections were scheduled during the day; two in the morning and two in the afternoon. The morning classes were at 9 o'clock and 10 o'clock while the afternoon classes met at 1 o'clock and 2 o'clock. Each of the classes met daily for 48 minutes.

The students attended 49 class meetings; five were used for reviewing, four for testing, and forty days for developing the concepts contained in fifty sections of the text which comprised the content of the Mathematics 150 course. All of the students in the four sections took common midterms in the same room at noon on the regularly scheduled examination days. They did not
attend classes on those three days.

On the first day of the quarter, the two members of the mathematics faculty who taught the four sections of the course met their classes, administered the study habits and attitude pretests, distributed the syllabi for the course, and made a reading assignment. The achievement pretest was administered on the second day of classes. One instructor taught the 9 o'clock and 2 o'clock classes. The other taught at 10 o'clock and 1 o'clock. Each instructor taught one experimental and one control group. By a flip of a coin the 9 o'clock class was designated as the experimental group for one instructor. The 2 o'clock class automatically became the control group for that instructor. A crossover pattern for assigning the experimental and control treatments to groups was used to check any bias that might occur from assigning both experimental treatments to morning groups and both control treatments to afternoon groups or vice versa. Students who elected to take mathematics in the morning might be different from students who chose to take mathematics in the afternoon. (For example, they might have been fresher and more alert in the morning than in the afternoon.) Consequently, the other instructor was assigned the control treatment with the 10 o'clock class and the experimental treatment with the 1 o'clock class.
All of the classes met in two rooms on the same floor in the same building. The morning classes used one room and the afternoon classes used the other room. The author and the two instructors met and agreed that the instructors would try to control bias and possible contamination by not introducing topics which were not scheduled, by not giving special instruction to one class and not the other, and by not distributing supplemental material without the permission of the author. Also discussed were possible answers that could be given the students when they asked about the different methods used in the assignments of homework. The author was not involved in the instructional aspects of the course, but acted as an adviser and consultant. One of the instructors has not taught for The Ohio State University previously. The other instructor taught at the Lima Campus the previous two years.

The students were administered the posttests in attitude and study habits and were given an information gathering questionnaire on the next-to-last day of classes.

Subjects

The subjects used in this study were the 88 students who received final grades in the Mathematics 150 course at the Lima Campus of The Ohio State University during the Autumn Quarter, 1971. Ninety-seven students took the
first midterm of the course. Of the 9 students who dropped the course, 5 were in the 2 o'clock class; 3 were in the 9 o'clock class; and 1 was in the 1 o'clock class. That made a total of 4 from the experimental group and 5 from the control group. Table 4 gives the sex and rank classification of the subjects by class.

TABLE 4

SEX AND RANK CLASSIFICATION OF MATHEMATICS 150 STUDENTS BY CLASS FOR AUTUMN QUARTER, 1971

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SEX</th>
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<th>SOPH.</th>
<th>JR.</th>
<th>SPECIAL</th>
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<tr>
<td>9</td>
<td>MALE</td>
<td>21</td>
<td>6</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>FEMALE</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>MALE</td>
<td>13</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>FEMALE</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>MALE</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>FEMALE</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>MALE</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>FEMALE</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

The subjects were 63.6 per cent male freshmen, 20.5 per cent sophomores, 9.1 per cent female freshmen, 3.4 per cent female sophomores, 2.3 female juniors, and 1.1 per cent male special (continuing education) students. This type of distribution is fairly normal for Mathematics 150 courses.
Assignment of Subjects

Random sampling of the subjects from the student population enrolled for Mathematics 150 was not possible. Also random assignment of the subjects to the Experimental and Control Groups was not possible because of the scheduling procedures at The Ohio State University. The placement of the students into the 9 o'clock, 10 o'clock, 1 o'clock or 2 o'clock sections was done by the Office of the Registrar and was not subject to any experimental control. The students indirectly choose their respective times when they registered for Autumn quarter classes. The students were assigned to rooms via class schedules with room numbers and instructors listed for all courses offered at the Lima Campus. These schedules were available to all students prior to the beginning of the Autumn Quarter.

Assignment of Instructors

The times of the sections of the Mathematics 150 course were firmed during the Spring Quarter, 1971, when the master schedule for the entire 1971-72 school year was developed. At that time it was not known who would be teaching the classes. The assignment of instructors to courses was made during the summer, 1971, after the two openings in the Mathematics Department were filled.
The instructors were assigned to the sections not by design for the study but in the natural development of a workable schedule. Since each of the instructors taught one experimental and one control class and a crossover pattern of assignment of treatments was used, the author believes that no conscious bias was introduced in the assignment of instructors.

**Control Treatment**

The control treatment was a method of assigning homework problems via a course syllabus. (Appendix A) On the first day of the quarter, each student in the control group received a syllabus with the section and corresponding homework problems from the text listed by a daily schedule for the entire quarter. Additional information in the syllabus was dates of the vacation days, review days, and examination days. This method of assigning mathematics problems by way of a syllabus is common practice at universities such as The Ohio State University. It will be referred to as the control or 'usual' method.

The control group, designated as the C group, consisted of the 26 students in the 10 o'clock class and the 13 students in the 2 o'clock class who received the control treatment.

**Experimental Treatment**

The experimental treatment was a "personalized"
method of assigning homework problems.

The primary characteristics of the personalized method were test-like questions, references to the students' environment, consolidating the problems and supplying answers, and building a review of each week's work into the problems.

The E group consisted of the 30 students in the 9 o'clock class and the 19 students in the 1 o'clock class. On the first day of classes, each student in the E, (experimental) group received a syllabus for the course. (Appendix A) This syllabus was quite similar to the one given to the C (control) group. It contained the same information given the C group except that the homework assignments were deleted. The author constructed the homework problems for the experimental group. (Appendix B) The problems were patterned closely after the textbook assignments for the C group. For example, if the second problem for the C group was to find a side of an acute triangle, then the second problem for the E group was to find a side of an acute triangle. But the manner in which the homework problems were presented and distributed to the E group was the essence of the experimental treatment and was quite different from the impersonal, routine method in which the C group received its assignments -- all at one time at the beginning of the quarter. The assignments for the E group were compiled and consolidated by section and distributed to the students on Xeroxed handouts by the
instructors on the day that the section was assigned. If more than one section was assigned on a particular day, a corresponding number of handouts was distributed on that day. Answers were provided for the E group to problems that corresponded to problems of the C group for which the book supplied answers. For example, if the C group was assigned problems 1a, b, c, c2, e, f and the book provided answers for only 1a and 1e and if problems 1 and 5 for the E group were the comparable problems to 1a and 1e, then answers were provided for the E group for only problems 1 and 5. The homework assignments for the E group were further personalized by using a variety of formats for framing the questions; formats such as combinations of multiple choice, matching, completion, short answers, true or false, and verifying equations were used. References to the students' environment such as characteristics and landmarks of the Lima Campus and surrounding communities and references to their mathematics instructors were used in some of the problems and a review of each week's work was built into the last problem set of that week for the experimental group.

In summary, the experimental treatment was a personalized method of presenting homework assignments. The primary characteristics of the personalized method were test-like questions, references from the students' environment, consolidating the problems and supplying
answers, and building a review of each week's work into
the problems.

Controls

Since true randomization could not be achieved in
assigning subjects to treatments, this experiment is
called quasiexperimental. (6,2)

Each group was assigned problems covering approximate­
ly the same concepts, in about the same numbers and on the
same days and so pacing seems to have been controlled.
The instructors distributed E group assignments only to
students in their own E group, but there is no way of
knowing whether the students shared the assignments with
students in the C group. The author does not believe that
there was any wide-scale sharing since neither he nor
either of the instructors heard about any sharing of the
problems even though a fairly good grape vine exists on
the Lima Campus. The instructors made a conscious effort
not to bias the study by showing favorable attention, giving
extra consideration, or distributing supplemental materials
to only one of their sections at any time. The subjects
of this study seem to be fairly homogeneous with respect
to age, rank, educational background, and participation
in community activities. Therefore, the author does not
feel that any undue bias of interaction of selection and
maturation existed. In compliance with the results of a
study on massed versus distributed homework assignments by
Laing (34) and the remark made in the report of the Cambridge Conference on School Mathematics on the review that should be included in the homework, the handouts to the experimental group on the last day of classes each week had one problem from each section covered during that week. Since each of the examinations was scheduled on Thursday, placing the review in Friday's homework should have minimized the effect of teaching for the examination per se. The crossover pattern of assigning treatments to groups should have controlled bias which might be caused by the time of day the student took the course. Because the study is of quasiexperimental design, the external validity of the experiment is poor, but the experimenter feels that adequate controls have been placed on the experiment to insure internal validity.

Tests and Measures

The Mathematics Study Habits Questionnaire (Appendix C) was experimenter-designed. It had a reliability of 0.837 as determined by a split-halves correlation and the Spearman-Brown Prophesy Formula. The attitude instrument was the Shatkin Attitude Test (Appendix E), a standardized instrument with a reported reliability of .972 (58). The achievement test used as a pretest and posttest was a subset of a final examination used in the Mathematics 150 course on the Columbus Campus, Winter Quarter, 1971. The midterms of this course were also
patterned after midterms used on the Columbus Campus, Winter Quarter, 1971. The achievement pretest-posttest was constructed by checking the concepts tested in each of the 40 questions on the afore mentioned final examination and narrowing the number to 22 questions which the author felt adequately dealt with the content in the course. The pretest had to be short enough to allow the students to finish it in one class period. The author distributed the achievement test to two members of the faculty who had taught the Mathematics 150 course previously for their critical remarks. They did not suggest any changes and said that they felt the subtest did cover the basic concepts of the course. In constructing the three midterms, the author chose problems from the examinations obtained from Columbus that corresponded with concepts which were taught on the Lima Campus. Some problems had to be eliminated because they asked questions about concepts not dealt with in the text, concepts that were developed by the television instructor in Columbus. Other problems were substituted for those eliminated to insure that each midterm contain 20 questions. The final examination was constructed in much the same way except the 22 questions which had been used on the pretest were the first 22 questions on the final examination. The exams were given to each instructor in the study to check for their approval. They each had veto power over any of
the questions on the examinations except for the first 22 questions on the final examination, the pretest-post-test. One of the instructors had already approved these questions on the pretest. All questions on all of the examinations were multiple choice. The students of all four sections met in a large auditorium at noon on the days that the midterm examinations were scheduled. They were first given Ohio State University Office of Evaluation answer sheets and were instructed in filling in pertinent data. They had been told ahead of time to bring pencils to fill in the answer sheets because the tests would be machine graded. The instructors monitored the examinations. The students were then given their examination at the bell and had 55 minutes in which to complete the examination. When they had finished or when time had expired if they had not finished, they handed in only their answer sheets. They kept the examination and as they left the room they were given an answer sheet for the exam. They could immediately check to determine their score. Tight security measures were enforced to insure no one returned to the room after leaving. Table 5 gives the means ($\bar{x}$), standard deviations ($s$), ranges ($r$), reliability coefficients (both KR 20 and KR 21), and total possible points (TPP) for the sex achievement examinations.
## TABLE 5

**ACHIEVEMENT EXAMINATIONS DATA**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>PRETEST</th>
<th>POSTTEST</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>FINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>E₂</td>
<td>[5.62]</td>
<td>14.00</td>
<td>10.88</td>
<td>13.33</td>
<td>10.32</td>
<td>25.31</td>
</tr>
<tr>
<td></td>
<td>s 2.19</td>
<td>3.17</td>
<td>2.68</td>
<td>2.89</td>
<td>2.58</td>
<td>4.98</td>
</tr>
<tr>
<td></td>
<td>r 2-10</td>
<td>7-20</td>
<td>8-16</td>
<td>7-18</td>
<td>5-17</td>
<td>13-36</td>
</tr>
<tr>
<td>E₁</td>
<td>[5.00]</td>
<td>13.74</td>
<td>12.41</td>
<td>14.79</td>
<td>11.11</td>
<td>24.84</td>
</tr>
<tr>
<td></td>
<td>s 2.39</td>
<td>3.34</td>
<td>2.84</td>
<td>3.24</td>
<td>4.04</td>
<td>6.34</td>
</tr>
<tr>
<td></td>
<td>r 1-9</td>
<td>8-19</td>
<td>8-18</td>
<td>8-19</td>
<td>4-19</td>
<td>13-34</td>
</tr>
<tr>
<td>C₂</td>
<td>[6.31]</td>
<td>15.31</td>
<td>11.82</td>
<td>13.88</td>
<td>11.55</td>
<td>26.69</td>
</tr>
<tr>
<td></td>
<td>s 2.16</td>
<td>2.84</td>
<td>2.59</td>
<td>4.09</td>
<td>3.94</td>
<td>4.76</td>
</tr>
<tr>
<td></td>
<td>r 3-10</td>
<td>9-21</td>
<td>9-17</td>
<td>8-18</td>
<td>4-16</td>
<td>18-35</td>
</tr>
<tr>
<td>C₁</td>
<td>[5.04]</td>
<td>12.27</td>
<td>11.63</td>
<td>12.92</td>
<td>9.08</td>
<td>22.77</td>
</tr>
<tr>
<td></td>
<td>s 2.22</td>
<td>2.98</td>
<td>2.30</td>
<td>3.16</td>
<td>3.06</td>
<td>5.60</td>
</tr>
<tr>
<td></td>
<td>r 0-10</td>
<td>6-18</td>
<td>8-16</td>
<td>6-18</td>
<td>3-14</td>
<td>13-33</td>
</tr>
<tr>
<td></td>
<td>s 2.29</td>
<td>3.24</td>
<td>2.85</td>
<td>3.08</td>
<td>3.22</td>
<td>5.56</td>
</tr>
<tr>
<td></td>
<td>r 1-10</td>
<td>7-20</td>
<td>8-18</td>
<td>7-19</td>
<td>4-19</td>
<td>13-36</td>
</tr>
<tr>
<td>C</td>
<td>[5.46]</td>
<td>13.28</td>
<td>11.70</td>
<td>13.29</td>
<td>9.83</td>
<td>24.08</td>
</tr>
<tr>
<td></td>
<td>s 2.23</td>
<td>3.27</td>
<td>2.42</td>
<td>3.57</td>
<td>3.54</td>
<td>5.64</td>
</tr>
<tr>
<td></td>
<td>r 0-10</td>
<td>6-21</td>
<td>8-17</td>
<td>6-18</td>
<td>3-16</td>
<td>13-35</td>
</tr>
</tbody>
</table>

KR 20 0.348 0.644 0.479 0.727 0.663 0.784

KR 21 0.240 0.538 0.331 0.685 0.592 0.719

TPP 22 22 20 20 20 40
The author also used a data gathering questionnaire (Appendix F) the next to last day of classes. The results of this questionnaire will be analyzed in the next chapter. Also, the experimenter asked the instructors to record their ideas about the experiment. This information will also be reported in Chapter V.

Chapter V will report the results of the study by an analysis of the data under the design of the study and also by pertinent informal and anecdotal information about the study. Significance levels obtained for each result will be reported. A two-way analysis of covariance will be used to test for $A_t$. Tests made on the gain scores in attitude and achievement will be $t$ tests corrected for correlated samples. The study habits questionnaire will be submitted to a correlational analysis.
CHAPTER V
ANALYSIS AND INTERPRETATION OF THE DATA

This chapter consists of two main sections: the first contains an analysis and interpretation of the data pertaining to the hypotheses set forth in Chapter I; the second contains additional data gathered on the study habits questionnaire, a homework opinionnaire, and comments about the treatments from the instructors and their students. Levels of significance up to 0.20 (the limit of the t-tables) will be reported for each analysis.

Data on quality points, ACT Mathematics scores, and scores on the Ohio State University Mathematics Placement Examination were collected. Most of the subjects took the D form of the Mathematics Placement Examination. No conversion scale for scores on the two forms of the placement examination could be found.

**Quality Points**

The quality points for the students were obtained from lists of data pertaining to entrance examination scores supplied by the Office of Orientation and Testing, The Ohio State University. Data missing from the lists were obtained directly from the students' transcripts.
The information on quality points is given in Table 6. The quality points were available for all but one student who was registered as a special student.

**TABLE 6**

**QUALITY POINTS**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>48</td>
<td>22.27</td>
<td>5.15</td>
<td>0.1753</td>
<td>p &gt; 0.20</td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>22.49</td>
<td>6.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The difference between the two groups with respect to quality points was not found to be significant at or below the 0.20 level. The two groups are considered statistically equivalent with respect to quality points.

**ACT Scores**

The ACT Mathematics scores were, as the quality points, used as a measure of prior mathematical achievement. These two variables are used as covariates when testing the hypotheses on total achievement. ACT scores for the E and C groups are presented in Table 7.

The ACT scores favored the E group, but the .13 level is not considered statistically significant. Moreover, ACT scores are used as a covariate in testing for significance with respect to total achievement.
### TABLE 7
DISTRIBUTION OF ACT MATHEMATICS SCORES

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>48</td>
<td>26.88</td>
<td>3.18</td>
<td>1.5781</td>
<td>p &lt; 0.13</td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>25.72</td>
<td>3.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mathematics Placement Scores

As described earlier, each student entering The Ohio State University as a freshman placed at one of five mathematics levels by examination. The form of the examination (B or D) was determined by the students' ACT mathematics scores. Table 8 compares the placement scores of the groups on each form. A majority of the students (E - 83.33 per cent, C - 71.79 per cent) took the D form.

### TABLE 8
DISTRIBUTION OF MATHEMATICS PLACEMENT SCORES

<table>
<thead>
<tr>
<th>Form</th>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>E</td>
<td>40</td>
<td>8.18</td>
<td>3.18</td>
<td>0.2967</td>
<td>p &gt; 0.20</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>28</td>
<td>8.39</td>
<td>2.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>E</td>
<td>8</td>
<td>21.75</td>
<td>7.41</td>
<td>0.8903</td>
<td>p &gt; 0.20</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>11</td>
<td>18.55</td>
<td>7.49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results of the placement examinations slightly favored the C group; however, the results were mixed and not significantly different at or below the 0.20 level. Since no conversion scale for scores on the two forms of the placement test could be found, the placement scores are not used as a covariate in testing any of the hypotheses.

The two groups of students are considered to be statistically equivalent with respect to prior mathematical achievement.

ANALYSIS AND INTERPRETATION OF HYPOTHESES-RELATED DATA

The tests of hypotheses reported in this section are presented in the same order as in Chapter I. The first hypothesis tested is that there is no significant difference between the E and C groups with respect to any change in the ranking of importance of homework as measured in Part I on the pre and post study habits questionnaire. Part I of the Mathematics Study Habits Questionnaire reads

I. Rank the following as you see them as contributing to your understanding of mathematics; 1-most important, 2-next most important, and 3-least important.

________ Reading the text

________ Doing the homework

________ Attending lecture

Since the students ranked the variables from most important to least important, the variables with the low-
est means are considered the most important in contributing to the understanding of mathematics. The data is presented in Table 9. ( $\bar{x}$ - mean, $s$ - standard deviation)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>E</td>
<td>49</td>
<td>$\bar{x} = 2.2857$</td>
<td>$\bar{x} = 2.3673$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$s = 0.7559$</td>
<td>$s = 0.8254$</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>39</td>
<td>$\bar{x} = 2.5385$</td>
<td>$\bar{x} = 2.2564$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$s = 0.7105$</td>
<td>$s = 0.8687$</td>
</tr>
<tr>
<td>Homework</td>
<td>E</td>
<td>49</td>
<td>$\bar{x} = 1.8776$</td>
<td>$\bar{x} = 1.8367$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$s = 0.7988$</td>
<td>$s = 0.6498$</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>39</td>
<td>$\bar{x} = 1.7692$</td>
<td>$\bar{x} = 1.7692$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$s = 0.7324$</td>
<td>$s = 0.6965$</td>
</tr>
<tr>
<td>Lecture</td>
<td>E</td>
<td>49</td>
<td>$\bar{x} = 1.8367$</td>
<td>$\bar{x} = 1.7755$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$s = 0.8168$</td>
<td>$s = 0.8394$</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>39</td>
<td>$\bar{x} = 1.6667$</td>
<td>$\bar{x} = 1.9744$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$s = 0.6918$</td>
<td>$s = 0.8002$</td>
</tr>
</tbody>
</table>

As can be seen from Table 9, both groups considered the text to be the least important of the three variables on the pretest and the posttest. The lecture variable was considered most important by both groups on the pretest. On the posttest, the C group ranked the lecture as second
most important while the E group again ranked the lecture as the most important. The E group ranked lecture as more important on the posttest than on the pretest, but the control group ranked the lecture as less important on the posttest than on the pretest. One instructor commented that he felt the experimental treatment inspired the students and therefore caused his E group to be extremely lively and to enter into discussions about the homework problems and the material in the text. He further stated that his C group was rather "dead". This may have led the E students to rank the lecture as most important even though the experimental treatment motivated the mood for the lectures. It should be noted that the control group had identical means on the homework variable on the pretest and the posttest while the experimental group ranked homework slightly more important on the posttest than on the pretest. In summary of Table 9, both groups ranked the three variables in exactly the same order on the pretest, but on the posttest an interchange of the rankings of homework and lecture was found in the C group.

Since the homework variable is of primary concern in this study, the ranking of the homework variable is examined more closely. In analyzing any change of the ranking of the homework variable, the Chi Square test was chosen instead of the t-test because the Chi Square test uses the changes in each category (1, 2, or 3) of the
ranking. A test for independence for the homework variable was run. The results are presented in Table 10. The number of students ranking the homework variable in each category is given by group. The number of responses expected if the ranking is independent of the group is presented in parenthesis.

TABLE 10

TEST OF INDEPENDENCE - HOMEWORK VARIABLE

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Students In Each Category</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>(19.49)</td>
<td>(18.38)</td>
</tr>
<tr>
<td>C</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>(15.51)</td>
<td>(14.63)</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>33</td>
</tr>
</tbody>
</table>

A Chi Square score of .960 and a p value greater than 0.63 were calculated. Therefore, the two groups are considered independent on the pretest and the pretest scores are used as the expected scores for the posttest. Table 11 reports the Chi Square analysis of the change in the ranking of the homework variable by the E and C groups from the pretest to the posttest.
The results of Table 11 reveal that hardly any change in the ranking of homework occurred in the C group. However, a decided shift upward from the ranking of 3 by the E group is noted. Also a shift downward from the ranking of 1 is observed. This latter shift might be explained in part by the indirect effect the experimental treatment may have had on the lecture variable. (See page 77) The change in the ranking of homework is significant in the E group. Therefore, the null hypotheses $H_0^1$, that there is no significant difference between the E and C groups with respect to any change in the ranking of importance of homework is rejected at the 0.01 level of significance. The data on the ranking of the homework variable was
analyzed by instructor also. The test for independence of ranking of the homework variable is given in Table 12.

**TABLE 12**

**TEST OF INDEPENDENCE - HOMEWORK VARIABLE**
**BY INDIVIDUAL INSTRUCTOR**

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Group</th>
<th>Number of Students In Each Category</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>I</td>
<td>E</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>II</td>
<td>E</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17</td>
<td>14</td>
</tr>
</tbody>
</table>

Chi Square scores of 0.280 and 0.412 and p values greater than 0.80 were calculated for the respective groups by instructor. Therefore, the groups with respect to instructor are considered independent on the pretest ranking of the homework variable and the pretest scores are used as expected scores for the posttest.

Table 13 reports the Chi Square analysis of the change in the ranking of the homework variable by the E and C groups with respect to the individual instructor.
**TABLE 15**

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Group</th>
<th>Rankings</th>
<th>Posttest Observed</th>
<th>Pretest Expected Sq.</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>E</td>
<td>2</td>
<td>12</td>
<td>8</td>
<td>6.08</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>11</td>
<td>11</td>
<td></td>
<td>1.36</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>13</td>
<td>11</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>8</td>
<td>12</td>
<td></td>
<td>5.77</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>15</td>
<td>9</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>C</td>
<td>1</td>
<td>4</td>
<td></td>
<td>0.45</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>5</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examination of Table 13 reveals that while the C group remained fairly stable in its ranking of the homework variable, there was a significant change below the 0.06 level in the E group with respect to each of the instructors. In ranking of the homework variable, there was a significant difference between the E and C groups, total (p < 0.01) and by individual instructors (p < 0.05 and p < 0.06), with respect to the change in the ranking of the homework variable on part one of the Mathematics Study Habits Questionnaire. Therefore, the null hypothesis
H_0, that there is no significant difference between the E and C groups with respect to any change in the ranking of importance of homework, is rejected at the 0.06 level of significance for the individual instructors and at the 0.01 level for the total groups.

The second hypothesis tested concerns any change in attitude as measured by a standardized attitude test with reported reliability of 0.972. The attitude scores, resulting t-statistics, and probabilities are presented in Table 14 by individual instructor and by total group. The attitude scores were lower on the posttest than on the pretest for all sections. However, the results do not favor either treatment or teacher uniformly.

TABLE 14
ATTITUDE SCORES

<table>
<thead>
<tr>
<th>Group-Instructor</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff. Score</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-1</td>
<td>19</td>
<td>71.32</td>
<td>61.26</td>
<td>-10.06</td>
<td>1.375</td>
<td>&gt;.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.79</td>
<td>16.63</td>
<td>15.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-1</td>
<td>26</td>
<td>75.81</td>
<td>71.08</td>
<td>-4.73</td>
<td>10.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.23</td>
<td>18.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-11</td>
<td>29</td>
<td>80.48</td>
<td>75.17</td>
<td>-5.31</td>
<td>0.488</td>
<td>&gt;.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.56</td>
<td>16.82</td>
<td>14.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-11</td>
<td>13</td>
<td>87.77</td>
<td>80.31</td>
<td>-7.46</td>
<td>10.71</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.58</td>
<td>9.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>48</td>
<td>76.85</td>
<td>69.67</td>
<td>-7.18</td>
<td>0.055</td>
<td>&gt;.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.05</td>
<td>18.10</td>
<td>14.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>79.79</td>
<td>74.15</td>
<td>-5.64</td>
<td>10.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.34</td>
<td>16.75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examination of Table 14 reveals that the control group showed a smaller decrease in attitude than the experimental group, but the differences were slight, and so the null hypothesis $H_0^2$, that there is no significant difference between the $E$ and $C$ groups, total and by individual instructor, with respect to gain scores in the attitude test, is retained.

The third hypothesis tested is concerned with achievement gain scores as determined by the pre- and post-achievement test. The gain scores are considered by the individual instructor's classes as well as by the combined treatment groups. The information on the achievement variable is presented in Table 15.

**TABLE 15**

**GAIN SCORES ON ACHIEVEMENT VARIABLE**

<table>
<thead>
<tr>
<th>Group-Instructor</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Gain</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-1</td>
<td>19</td>
<td>x = 5.00</td>
<td>13.74</td>
<td>8.74</td>
<td>2.64</td>
<td>1.451</td>
<td>43 p&lt; .17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 2.39</td>
<td>3.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-1</td>
<td>26</td>
<td>x = 5.04</td>
<td>12.27</td>
<td>7.23</td>
<td>3.98</td>
<td>3.19</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 2.22</td>
<td>2.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-11</td>
<td>29</td>
<td>x = 5.62</td>
<td>14.00</td>
<td>8.38</td>
<td>3.17</td>
<td>3.24</td>
<td>0.599 40 p&gt; .20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 2.19</td>
<td>3.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-11</td>
<td>13</td>
<td>x = 6.31</td>
<td>15.31</td>
<td>9.00</td>
<td>3.44</td>
<td>2.74</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 2.16</td>
<td>2.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>48</td>
<td>x = 5.38</td>
<td>13.90</td>
<td>8.52</td>
<td>3.24</td>
<td>3.00</td>
<td>0.986 85 p&gt; .20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 2.29</td>
<td>3.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>x = 5.46</td>
<td>13.28</td>
<td>7.82</td>
<td>3.27</td>
<td>3.36</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>s = 2.23</td>
<td>3.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 15 reveals that the E group had a slightly higher gain than the C group. However, the results are mixed and most of this gain can be attributed to the classes of Instructor 1. Therefore, the achievement gain may have been more dependent upon an interaction of instructor with treatment than either of the variables independently. It should be noted that the instructor whose C group had the largest gain is the same one who said he felt he did a better job of teaching the control group because of his experience with the experimental group and also because the control group had only 13 students as compared with 29 in the experimental group. Therefore, the results may be somewhat biased. The other instructor stated that neither of his classes were "lively". The t-statistic reveals that the probability of obtaining the same results by chance are more than one in five and so the null hypothesis $H_0^3$, that there is no significant difference between the E and C groups, total or by individual instructor, with respect to gain scores on the achievement test - is retained.

The final hypothesis tested deals with total achievement in the course as measured on the sum of the standard scores on the three midterms and final examination of the course. Table 5 in Chapter IV gives the raw scores for each of the examinations. The raw scores were converted to standard scores with a mean of 500 and a standard
deviation of 100. The final examination was counted as two midterms and the five scores were added to obtain the total achievement score. Table 16 gives the total achievement data by individual instructor and by the total treatment group.

**TABLE 16**

**TOTAL ACHIEVEMENT SCORES**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>E₁</td>
<td>19</td>
<td>2623.2</td>
<td>502.7</td>
<td>1.7590</td>
<td>43</td>
<td>p&lt;.09</td>
</tr>
<tr>
<td>C₁</td>
<td>26</td>
<td>2387.5</td>
<td>396.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₂</td>
<td>29</td>
<td>2510.3</td>
<td>361.2</td>
<td>1.3304</td>
<td>40</td>
<td>p&lt;.20</td>
</tr>
<tr>
<td>C₂</td>
<td>13</td>
<td>2679.0</td>
<td>419.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>48</td>
<td>2555.0</td>
<td>421.4</td>
<td>0.7750</td>
<td>85</td>
<td>p&gt;.20</td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>2484.6</td>
<td>422.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An analysis of covariance was used to obtain the results summarized in Table 16. The equation for the analysis of covariance model is

\[ y_{ijk} = u + a_i + b_j + c_{ij} + \delta_1 x_{lijk} + \delta_2 x_{2ijk} + e_{ijk} \]

where

1. \( y_{ijk} \) is the dependent variable score \( A_t \) for the \( k \)-th student of the \( i \)-th instructor (\( i=1,2 \)) subjected to the \( j \)-th treatment (\( j=1,2 \))
2. \( u \) is the overall \( A_t \) mean score
3. \( a_i \) is the effect of the \( i \)-th instructor
4. \( b_j \) is the effect of the \( j \)-th treatment
5. \( c_{ij} \) is the interaction effect of the \( i \)-th instructor with the \( j \)-th treatment
6. \( \alpha_1 \) and \( \alpha_2 \) are constants
7. \( x_{1ijk} \) is the Mathematics ACT score and \( x_{2ijk} \) is the Quality points score for the \( k \)-th student of the \( i \)-th instructor subjected to the \( j \)-th treatment
8. \( e_{ijk} \) is the error adjustment for the \( k \)-th student of the \( i \)-th instructor with respect to the \( j \)-th treatment

In summary, this model expresses the individual students' \( A_t \) score as a function of the eight components listed above. The analysis of the covariance is given in Table 17.

Table 17 reveals that while neither the instructor nor the treatment variable alone had much effect, there was an interaction between the two. However, the interaction was not significant at the 5 per cent level. The two covariates were significant at the 1 per cent level whether considered singly or jointly.

Table 16 reveals that for the first instructor's classes the experimental group did better than the control group. Less than nine times in one hundred would this amount of difference in achievement be due to chance.
### TABLE 17
ANALYSIS OF COVARIANCE MODEL

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>1384590.23</td>
<td>1</td>
<td>1384590.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructor</td>
<td>9553.43</td>
<td>1</td>
<td>9553.43</td>
<td>0.08</td>
<td>n.s.</td>
</tr>
<tr>
<td>Treatment</td>
<td>26402.52</td>
<td>1</td>
<td>26402.52</td>
<td>0.21</td>
<td>n.s.</td>
</tr>
<tr>
<td>Interaction</td>
<td>223347.85</td>
<td>1</td>
<td>223347.85</td>
<td>1.79</td>
<td>n.s.</td>
</tr>
<tr>
<td>Cov. 1 (ACT)</td>
<td>929614.75</td>
<td>1</td>
<td>929614.75</td>
<td>7.43</td>
<td>1%</td>
</tr>
<tr>
<td>Cov. 2 (QP)</td>
<td>1166236.00</td>
<td>1</td>
<td>1166236.00</td>
<td>9.32</td>
<td>1%</td>
</tr>
<tr>
<td>Both Cov.</td>
<td>4107265.69</td>
<td>1</td>
<td>2053632.85</td>
<td>16.42</td>
<td>1%</td>
</tr>
<tr>
<td>Error</td>
<td>10132716.48</td>
<td>81</td>
<td>125095.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, for the other instructor's classes and the combined groups, similar results could happen twenty or more times out of one hundred due to chance. Therefore the null hypothesis $H_0$ that there is no significant difference between the E and C groups, total and by individual instructor, with respect to total achievement, is not rejected.

The analysis and interpretation of the data pertaining to the four main hypotheses are here concluded. Analysis and interpretation of parts II and III on the study habits questionnaire, a homework opinionnaire, and comments by the instructors and students are presented.
in the remaining part of this chapter.

Section II of the study habits questionnaire contains six statements pertaining to study habits. The students were asked to select one of three phrases to complete the statements of Sections II. Section II is presented here for reference to Table 18, which gives the number of responses to each answer to the statements. The answers are given, by group, for the pretest and the posttest.

II. Place the letter of the most appropriate answer in the answer column to the right.

1. Excluding test scores, I judge my standing in class on
   a) how well I do on my homework assignments
   b) how well I understand my readings
   c) how well I follow the lectures

2. When I study, I
   a) have the radio, record player, or television on
   b) require complete silence
   c) am in a room where others sometimes distract me

3. When doing homework, I rely mainly on what I learned
   a) in lecture
   b) by reading the text
   c) from previous mathematics courses

4. I study
   a) by myself
   b) with only one other student
   c) with more than one other student

5. I start my homework assignments
   a) as soon as possible after lecture
**TABLE 18**

RESPONSES TO SECTION II OF MATHEMATICS STUDY
HABITS QUESTIONNAIRE
(PER CENT IN PARENTHESES)

<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>POST</th>
<th>CHI</th>
<th>p</th>
<th>PRE</th>
<th>POST</th>
<th>CHI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. a</td>
<td>21(43)</td>
<td>30(61)</td>
<td>3.857</td>
<td>.03</td>
<td>20(51)</td>
<td>22(56)</td>
<td>0.200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14(29)</td>
<td>6(12)</td>
<td>4.571</td>
<td>.800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14(29)</td>
<td>13(27)</td>
<td>0.071</td>
<td>20(51)</td>
<td>14(36)</td>
<td>10(26)</td>
<td>1.143</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.499</td>
<td>.200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. a</td>
<td>9(18)</td>
<td>12(24)</td>
<td>1.000</td>
<td>.778</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23(47)</td>
<td>22(45)</td>
<td>0.043</td>
<td>.200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17(35)</td>
<td>15(31)</td>
<td>0.235</td>
<td>1.143</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1.278</td>
<td>.200</td>
<td></td>
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</tr>
<tr>
<td>3. a</td>
<td>28(57)</td>
<td>32(65)</td>
<td>0.571</td>
<td>.07</td>
<td></td>
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<tr>
<td></td>
<td>15(31)</td>
<td>13(27)</td>
<td>0.267</td>
<td>.200</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6(12)</td>
<td>4(8)</td>
<td>0.667</td>
<td>1.000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.505</td>
<td>.200</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4. a</td>
<td>44(90)</td>
<td>47(96)</td>
<td>0.205</td>
<td>.000</td>
<td></td>
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<tr>
<td></td>
<td>2( 4)</td>
<td>1( 2)</td>
<td>0.500</td>
<td>1(3)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0(0)</td>
<td>1(0)</td>
<td>1(3)</td>
<td>1.000</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>2.038</td>
<td>.200</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5. a</td>
<td>22(45)</td>
<td>13(27)</td>
<td>3.682</td>
<td>2.579</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0(0)</td>
<td>1(2)</td>
<td>0(0)</td>
<td>2(5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27(55)</td>
<td>35(71)</td>
<td>2.370</td>
<td>1.250</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.052</td>
<td>.05</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6. a</td>
<td>15(31)</td>
<td>11(22)</td>
<td>1.067</td>
<td>1.067</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>14(29)</td>
<td>11(22)</td>
<td>0.643</td>
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<tr>
<td></td>
<td>20(41)</td>
<td>27(55)</td>
<td>2.450</td>
<td>6.750</td>
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<tr>
<td></td>
<td>4.160</td>
<td>.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The expected value would have been zero and no Chi Square could be calculated. These categories have been dropped from the analysis. Higher levels of significance were obtained in these three cases. Therefore, the results are conservative.
b) the latest possible time before the next lecture
c) other

6. I do my homework

a) all at one time
b) with infrequent interruptions
c) without a set pattern

The data in Table 18 reveal that the students in both treatment groups judged their standing in class in about the same way. A majority in each group chose how well they did on homework assignments as the primary criterion for judging their standing in class. The E group showed a 43 per cent increase in the number of students who selected performance on homework assignments as the major criterion for assessing standing in class compared with only a 10 per cent increase for the C group. The increase in the E group was significant at the 3 per cent level, but the increase in the C group was not significant at or below the 20 per cent level. The students in the two groups seem to have or require approximately the same conditions for their study environment (Statement 2); however, the C group showed an increase in the number of students who studied in a room where they were sometimes distracted while the E group showed a decrease in that category. It is not known whether the format of the homework is associated with this difference. Results of statement 3 appear to indicate that the students receiving
the handout assignments relied more on the lecture and less on reading the text as preparation for doing the homework problems than did the students in the control group. The results of statement 4 are as were expected, since the students at the Lima Campus are all commuter students. Both groups reacted about the same to statement 5. They seem to have no set pattern as to when they begin their assignments. The results of statement 6 seem to support the no pattern approach to starting or doing the homework assignments. The responses of the two groups were quite similar on statement 6. The results were shown to and discussed with a psychology professor at the Lima Campus. She stated that these results supported some of her conjectures about study habits of the students in general and she agreed with the author that a "how to study" course should be offered to the students.

Section III of the mathematics study habits questionnaire has 26 statements. Eleven of the statements (1-6, 8, 13, 17, 21, 25) are positive-oriented and the other fifteen are negative-oriented. The responses to the statements were given numerical values as follows: on the positive-oriented statements H - 1, S - 2, F - 3, U - 4, A - 5 and on the negative-oriented statements H - 5, S - 4, F - 3, U - 2, A - 1. Therefore, higher numerical values were associated with stronger study habits. The statements are listed here for reference.
1. When studying for an examination, I arrange my material in some logical order.

2. Even though I may not like mathematics, I work very hard at it.

3. I stick with my assignment even if it is dull and boring to me.

4. I outline the main points of my notes from lecture and from my readings.

5. I copy the examples and diagrams my instructors place on the chalkboard.

6. When I get behind in my assignments for some reason, I make up the back assignments on my own.

7. I am easily distracted from my studies by daydreaming of more important or pressing things.

8. I use my homework assignments as a guide for the amount of studying I should do.

9. I lay aside homework assignments and returned examinations without checking to see what my errors are.

10. I do not feel that I have time to, or should take the time to, do all of my mathematics homework.

11. When reading the text, I skip over examples, tables, and graphs.

12. When checking my assignments and exams, I find that my own carelessness is my biggest downfall.

13. I do my assignments regularly each day as they are assigned.

14. I do poorly on mathematics tests because that is the first time I am confronted with all the material at one time.

15. I do not seem to accomplish much in relation to the amount of time I spend studying mathematics.

16. When reading the text, my mind wanders and I am unable to recall much of what I have just read.

17. By organizing my work at the beginning, I get the most out of my study time.
18. I memorize definitions, rules, proofs, formulas, etc., without really understanding them.

19. The hardest part of doing my assignments is getting myself mentally set to start.

20. I do not work any harder than I feel I have to in order to receive a passing grade.

21. I feel that my grades are an accurate description of my ability in mathematics.

22. I do well on my assignments, but for some reason I do not do as well on examinations.

23. I hesitate to ask my instructors to explain an assignment or example that is not clear to me.

24. I start each new mathematics course with a dread of impending doom.

25. I use my homework assignments as the primary source for studying for examinations.

26. I do not see any relevance in the mathematics I study as to what I plan to do.

The means for each of the 26 statements were calculated for both groups on the pretest and the posttest. The rank of the statements and their corresponding means are given in Table 19. The statement number is followed by the mean in parentheses.

The range of the means in Table 19 are: Pretest - 2.5000 to 4.7917; Posttest - 2.1667 to 4.5641. Further examination of Table 19 reveals that both groups seem to have somewhat similar perceptions about their study habits with respect to mathematics. The top and bottom three rankings of both groups are identical on the posttest.

Statement 15, "I do poorly on mathematics tests because that is the first time I am confronted with all
<table>
<thead>
<tr>
<th>Rank</th>
<th>Pre</th>
<th>E</th>
<th>Post</th>
<th>Pre</th>
<th>C</th>
<th>Post</th>
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<tbody>
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<td>9</td>
<td>4.5417</td>
<td>10</td>
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<td>26</td>
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<td>4.4872</td>
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<td>14</td>
<td>4.0208</td>
<td>5</td>
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<td>6</td>
<td>1,24</td>
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<td>2,18</td>
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<tr>
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<td>16</td>
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<td>4.0256</td>
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<td>3.9231</td>
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<td>3.8462</td>
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<td>3.7436</td>
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<td>3.3590</td>
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<tr>
<td>18</td>
<td>22</td>
<td>3.5641</td>
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<td>3.3077</td>
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<td>3.3077</td>
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<tr>
<td>19</td>
<td>6</td>
<td>3.5208</td>
<td>4</td>
<td>3.3333</td>
<td>8</td>
<td>3.2821</td>
</tr>
<tr>
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<td>8</td>
<td>3.4375</td>
<td>17</td>
<td>3.2292</td>
<td>25</td>
<td>3.2564</td>
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<td>3.3125</td>
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<td>3.1042</td>
<td>17</td>
<td>3.0769</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>3.1875</td>
<td>19</td>
<td>2.8958</td>
<td>3</td>
<td>3.0513</td>
</tr>
<tr>
<td>23</td>
<td>19</td>
<td>3.1250</td>
<td>12</td>
<td>2.3750</td>
<td>21</td>
<td>2.9487</td>
</tr>
<tr>
<td>24</td>
<td>21</td>
<td>2.6667</td>
<td>3</td>
<td>2.2500</td>
<td>19</td>
<td>2.8718</td>
</tr>
<tr>
<td>25</td>
<td>12</td>
<td>2.5000</td>
<td>21</td>
<td>2.1667</td>
<td>12</td>
<td>2.7179</td>
</tr>
</tbody>
</table>
the material at one time", was changed from twelfth place on the pretest to fifth place on the posttest by the E group but was ranked in fourteenth place on both the pre- and posttest by the C group. This result may have been the effect of the review nature of the homework exercises for the E group. Likewise for statement 25, the E group ranked using the homework as the primary source for studying for examinations higher than the C group. This may have resulted from the format of and the review nature of the handout assignments. Statement 23 refers to hesitancy in asking the instructors for explanations. The C group was less hesitant than the E group. The instructors thought the reason might have been that the C group felt it needed more help and that the E group felt that since it had received a handout, the problems should be completed without help. Since the author can only speculate as to the reasons the groups responded differently to different questions, no further attempt at analyzing these differences will be made here. The reader may formulate his own conjectures. In summary of the post questionnaire results of Table 19, the students in both groups felt that their strongest study habits or attitudes listed in section III were (in order):

1. checking homework assignments and examinations to find their errors

2. examining examples, tables, and graphs when reading the text
3. working harder than necessary for receiving a passing grade
4. feeling that they should take the time to do all their mathematics homework
5. being able to read the text without their minds wandering and then being able to recall most of what they had just read
6. seeing relevance in the mathematics they study as to what they plan to do
7. not memorizing definitions, rules, proofs, formulas, etc. without really understanding them

They felt that their weakest study habits or attitudes were:

1. their grades are not an accurate description of their ability in mathematics
2. they do not outline the main points of their notes from lecture or from their readings
3. they find that carelessness is their biggest downfall in studying mathematics
4. the hardest part of doing their assignments is getting themselves mentally set to start
5. they do not organize their work at the beginning to get the most out of study time
6. they do well on assignments, but for some reason do not do well on examinations

Posttest correlations were constructed for statements in section III augmented with the $A_t$ score. For a sample size of 38 (G group) the 95 per cent confidence level for the population correlation coefficient $p$ to be different from 0 is for the sample coefficient $r$ to be greater than or equal to 0.321. If the sample size is 48 (E group) $r$ should be greater than or equal to 0.285. The E group post questionnaire correlations whose absolute
values equal or exceed 0.285 are listed in Table 20 as ordered triples $(a, b, c)$ where $a$ and $b$ represent statement numbers and $c$ is their correlation.

**TABLE 20**

<table>
<thead>
<tr>
<th>E GROUP POSTTEST CORRELATIONS OF STATEMENTS IN SECTION III OF THE MATHEMATICS STUDY HABITS QUESTIONNAIRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(1, 2, .350)$</td>
</tr>
<tr>
<td>$(1, 17, .327)$</td>
</tr>
<tr>
<td>$(2, 6, .479)$</td>
</tr>
<tr>
<td>$(2, 19, .404)$</td>
</tr>
<tr>
<td>$(4, 6, .307)$</td>
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<td>$(13, 19, .337)$</td>
</tr>
<tr>
<td>$(13, 27, .324)$</td>
</tr>
<tr>
<td>$(15, 24, .301)$</td>
</tr>
<tr>
<td>$(17, 22, .304)$</td>
</tr>
<tr>
<td>$(19, 24, .438)$</td>
</tr>
</tbody>
</table>

Examination of Table 20 reveals that of the 81 entries in the table, 7 have $r$ between .5 and .6, 17 have $r$ between .4 and .5, 39 have $r$ between .3 and .4 and 14 have $r$ between .285 and .3. Also 4 have $r$ between -.3 and
Statement 20 is correlated with 13 other statements while statements 21 and 26 do not correlate with any of the other statements. The mean number of correlations for all 27 items is 6.0. Table 21 gives the same information as Table 20 but for the C group. However, the $r$ required for the 95 per cent confidence level is .321.

### Table 21

<table>
<thead>
<tr>
<th>C GROUP POSTTEST CORRELATION OF STATEMENTS IN SECTION III OF THE MATHEMATICS STUDY HABITS QUESTIONNAIRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1, 2, .360)(1, 4, .335)(1,10, .353)(1,11, .357 )(1,12, .402)</td>
</tr>
<tr>
<td>(1,27, .335)(2, 3, .421)(2, 4, .400)(2, 5, .426 )(2,13, .510)</td>
</tr>
<tr>
<td>(4,25, .332)(5,25, .364)(6, 8, .462)(6,10, .398 )(6,11, .382)</td>
</tr>
<tr>
<td>(6,13, .493)(7, 9, .326)(7,14, .341)(7,16, .418 )(7,19, .642)</td>
</tr>
<tr>
<td>(8,10, .365)(8,13, .365)(9,14, .418)(9,16, .340 )(9,17, .353)</td>
</tr>
<tr>
<td>(9,23, .453)(9,24, .409)(9,27, .382)(10,12, .345 )(10,13, .515)</td>
</tr>
<tr>
<td>(13,25,.446)(14,15,.695)(14,16,.379)(14,18,.325 )</td>
</tr>
<tr>
<td>(14,22,.380)(14,23,.487)(14,24,.433)(14,27,.535 )</td>
</tr>
<tr>
<td>(15,18,.375)(15,21,.321)(15,22,.363)(15,23,.329 )</td>
</tr>
<tr>
<td>(15,24,.433)(15,27,.577)(16,23,.377)(17,24,.421 )</td>
</tr>
<tr>
<td>(18,23,.355)(18,24,.394)(18,27,.328)(20,22,.348)</td>
</tr>
<tr>
<td>(22,27,.325)(23,27,.331)(24,26,.328)</td>
</tr>
</tbody>
</table>
Examination of Table 21 reveals that of the 77 entries in the table, 2 have $r$ between .6 and .7, 4 have $r$ between .5 and .6, 20 have $r$ between .4 and .5, and 49 have $r$ between .321 and .4. Also 2 have $r$ between -.3 and -.4. Statement 14 is correlated with 10 other statements while each of statements 21 and 26 correlate with only one other statement. The mean number of correlations is 5.7.

Table 22, which is a lower diagonal matrix providing a cross reference for Table 20 and Table 21, is presented on the next page. The numbers in the rows and columns of the table refer to the statement numbers. A lower diagonal matrix is used since correlations have the reflexive and symmetric properties of relations. Since every statement correlates with itself with a $r$ equal to one, the diagonal of the matrix, which would be all ones, is not listed. An e, c, or b at the intersection of a row and column refers to the statements belonging to Table 20 only, Table 21 only, or to both tables respectively.

Another opinionnaire was administered to all the students during the next to last class meeting. The opinionnaire has six statements. The first four statements are designed to explore some of the students' feelings about the homework treatments. Statement 5 is dependent on the response to statement 4. Statement 6 asked the students to make any comments they wished
TABLE 22
CROSS REFERENCE CORRELATIONS FROM TABLE 20 AND TABLE 21

|   | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|    |
| 1 | b  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2 | c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3 | b  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4 | c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 5 | e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 6 | c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 7 | e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 8 | e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 9 | c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 10| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 11| b  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 12| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 13| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 14| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 15| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 16| b  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 17| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 18| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 19| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 20| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 21| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 22| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 23| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 24| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 25| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 26| c  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 27| e  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
about the treatment of homework in the course. The opinionnaire is presented below.

1. The homework assignments had
   a) too few problems       b) too many problems
   c) about the correct amount of problems

2. The homework problems adequately covered the material of the course
   a) seldom               b) sometimes       c) most of the time

3. Did you like the way the homework problems were presented?
   Yes_________            No_________

4. Did you use the homework problems in review?
   Yes_________            No_________

5. If you answered Yes to question 4, did you use the assignments to review
   a) every week           b) after every section
   c) before exams         d) other (specify)

6) On the reverse side of this paper, please make any comments you wish about the treatment of homework for this course. This will help us in future course design.

The number of responses to each of the first five statements is given in Table 23.

As can be seen from Table 23, a decided majority of each group felt that the homework assignments had about the correct number of problems. However 79.2 per cent
TABLE 23
RESPONSES TO HOMEWORK OPINIONNAIRE
(PER CENTS IN PARENTHESES)

<table>
<thead>
<tr>
<th>Statement</th>
<th>E</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>2 (4.2)</td>
<td>1 (2.6)</td>
</tr>
<tr>
<td>1. b</td>
<td>4 (8.3)</td>
<td>3 (7.7)</td>
</tr>
<tr>
<td>c</td>
<td>42 (87.5)</td>
<td>35 (89.7)</td>
</tr>
<tr>
<td>a</td>
<td>1 (2.1)</td>
<td>1 (2.6)</td>
</tr>
<tr>
<td>2. b</td>
<td>9 (18.7)</td>
<td>12 (30.8)</td>
</tr>
<tr>
<td>c</td>
<td>38 (79.2)</td>
<td>26 (66.7)</td>
</tr>
<tr>
<td>3. Yes</td>
<td>39 (81.3)</td>
<td>14 (35.9)</td>
</tr>
<tr>
<td>No</td>
<td>9 (18.7)</td>
<td>25 (64.1)</td>
</tr>
<tr>
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<td>30 (76.9)</td>
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<tr>
<td>4. No</td>
<td>6 (12.5)</td>
<td>9 (23.1)</td>
</tr>
<tr>
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<td>1 (3.3)</td>
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<td>5. b</td>
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<td>4 (13.3)</td>
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<tr>
<td>c</td>
<td>33 (78.6)</td>
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</tr>
<tr>
<td>d</td>
<td>1 (2.4)</td>
<td>0 (0.0)</td>
</tr>
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</table>

of the E group compared with 66.7 per cent of the C group felt the most of the time the problems adequately covered the material of the course. The results of question 3 show that the E group liked the way the homework problems were presented (81.3 per cent) while only 35.9 per cent of the C group stated that they liked the way the problems
were presented. This difference was analyzed by a test for significance of difference between two independent proportions for each instructor and for the total treatment groups. The results are listed in Table 24.

TABLE 24
PER CENT OF STUDENTS EXPRESSING A LIKING OF PRESENTATION OF HOMEWORK

<table>
<thead>
<tr>
<th>Group</th>
<th>E</th>
<th>C</th>
<th>z</th>
<th>p</th>
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<tr>
<td>Instructor 1</td>
<td>84.21</td>
<td>30.77</td>
<td>3.56</td>
<td>p &lt; .0004</td>
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<td>79.31</td>
<td>46.15</td>
<td>2.16</td>
<td>p &lt; .0308</td>
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<td>81.25</td>
<td>35.90</td>
<td>4.30</td>
<td>p &lt; .0001</td>
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Results of Table 24 show that the E students liked the method of presentation of their homework assignments significantly better than the C students liked the method of presentation of their homework assignments. This significant difference was found between the different treatment groups for each instructor and also between the total treatment groups.

The data of question 4 were also analyzed and the results are presented in Table 25.

Examination of Table 25 shows that in the case of each instructor and the total group, a higher per cent of the E students said they used the homework in review; however, none of the differences were significant.
Further examination of Table 23 shows that a decided majority of the students used their homework in review for examinations. A seventh question was asked of the E students. It was placed on the opposite side of the page from the first six statements. It asked, "Do you feel that the way your homework assignments were presented contributed more to your understanding of the course than the 'usual' (assigning directly from the text) method would have"? Affirmative replies were made by 80.8 per cent; 19.2 per cent replied negatively. These results are quite similar to the results of question 3 on the opinionnaire.

Statement 6 of the homework opinionnaire asked the students to make comments about the treatment of homework in the course. The two instructors were also asked to comment. The following is a summary of these comments. Twenty-nine C students and thirty-six E students made
comments. Eighteen of the C students said that not enough time was spent in going over problems. Only two E students made that claim. One of the instructors said, "A positive observable aspect of the experiment was that the students in classes receiving handout assignments tended to attempt all the problems before the next day's class. I did not find this to be the case in the control class." Most of the comments from the C group were negative. They stated that the problems were too hard and frustrating and that the instructors did not go into enough detail on the problems. They said that the assignments should better prepare them for the exams and that they could not use their homework in review. One student said that homework was a necessary pain and that the problems in the book were ambiguous. Only two positive statements were made by members of the C group. One student said, "Very reasonably handled", and another said, "Did prepare me for exams".

The comments from the E students were very positive. Several of the students' statements are listed below.

1. Handouts helpful but should contain answers for all problems.

2. I like the sheets. They give same surroundings as exams. Problems seem to work out by doing homework sheets.

3. Good - I made sheets into note book and have notes from lecture right with problems.

4. If I would have to do it again, I would want the math sheets.
5. More homework done in class — less emphasis on what I can read myself.

6. Homework sheets help prepare us for taking multiple choice exams.

7. Answers should not be on assignment.

8. Homework assignment sheets most effective. Enabled me to put things in logical order, especially for exams. Encouraged me to do my homework, because I felt that I had conquered something when I finished a sheet.

9. The homework assignments were very helpful in preparing for exams and generally learning the materials.

10. The way the problems were presented related the problems to each other.

11. Continue to give prepared homework assignments and include answers to all problems. Answers help build confidence. This method of teaching is better than the normal method.

12. I liked the way this program of math was presented which made it easy for me to keep up with what we were doing.

13. Homework was quite satisfactory. The problems were properly chosen to give the student the tool for understanding the section. They were neither too easy nor too difficult for the average student to solve. The discussion of the harder problems the next day helped a great deal.

14. Do not change it.

15. I feel it was a help to selected problems but I wish the test would follow the homework more closely.

16. I would like the assignments from the book.

17. I liked the presentation of homework problems on sheets given out every day. When reviewing for an examination, the student does not have to leaf through the book to find problems with which to work.

18. I liked for reviewing for exams; I feel that I wouldn't have studied as much if I were to do assignments directly from the book.

19. Homework should be presented as midterms were.
20. These assignments were good in that you could check your answer. I worked backwards from some answers. All answers should have been provided. Generally the homework did an adequate job of preparing me for exams.

21. Problems on assignments seem little related to questions on exams.

22. More inclined to do it all. Punched sheets can be readily kept together to ask questions in class. Homework can be used with notes to go back and pick up forgotten or unclear ideas before a test. I think the time spent in putting homework on a handout is worthwhile.

23. I thought the homework assignments enabled me to understand better the ideas in each section. On the whole the problems were good and followed the sections very well.

24. Questions on the homework from the day before should be answered on that day.

25. When you give us outside problems, we can read the book as well and learn twice as much.

These statements were taken directly from the comments of the students. As can be read from the comments, the E students were strongly in favor of the handout assignments. However, none of the students commented directly about any personalized characteristic of the assignments.

Both instructors said that they enjoyed their E class more than their C class. They said they felt the handouts made a difference in the atmosphere of the classroom. They both made a collection of the assignments and asked if they could use the assignments in future classes.

Even though the E students and the instructors felt that the assignments were very beneficial, the author is not convinced that the results in increased achieve-
ment by the E group with respect to the C group were im-
pressive enough to warrant all the time and energy expended
in creating the personalized homework assignments. Further
discussion of this will be presented in the next chapter.

The findings, conclusions, limitations and recommenda-
dations pertaining to the experiment will be presented in
Chapter VI.
CHAPTER VI

CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

The experiment described in the preceding chapters was an attempt to provide a partial answer to the question, Does a "personalized" format of mathematics homework assignments presented to college students in a pre-calculus integrated algebra and trigonometry course affect the students' attitude toward importance of homework in mathematics, attitude toward mathematics, and achievement in mathematics? Two treatment groups were used in this study. The C group received assignments from the text. The E group received assignments via daily Xeroxed handouts. These assignments were identical in mathematical content to those given to the C group but the problems for the E group were personalized and were expressed in the form of true-false, completion, matching, and/or short answer questions. Thus, the primary characteristics of the personalized method were test-like questions and references from the students' environment; problems were consolidated and controlled answers were supplied; and a review of each week's work was built into the problems.
CONCLUSIONS

The following conclusions were drawn from this study.

**Attitude Toward Importance Of Homework**

The experimental treatment was associated with an increase in the mean ranking of the importance of homework while the control treatment was associated with no change in the mean. A Chi Square analysis of the change showed a significant difference at the 1 per cent level for the E group between the ranking on the pretest and posttest. The greatest change in any category for the E group was in the number of students not ranking homework as the least important on the posttest. The experimental treatment seems to have had a positive effect on students who did not think that homework contributed much to their understanding of mathematics. This positive effect of the experimental treatment appeared to be independent of the instructor variable.

**Attitude Toward Mathematics**

Both groups had a lower score on the posttest than on the pretest. The differences were not significant at or below the 20 per cent level by either individual instructor or by the total group. The experimental group had the larger decrease. These results, combined with
those in the previous section, illustrate how attitudes toward one aspect (homework) of mathematics may increase while attitudes toward mathematics in general decrease.

**Achievement in Mathematics**

Achievement in mathematics was measured in two forms. $A_c$ was measured on difference scores determined by a pretest and posttest on the content of the course. The experimental group had a higher gain than the control group. The difference was not significant. The results seemed to be dependent upon an interaction between the treatment and instructor variables.

The other form was total achievement, $A_t$. It was measured on the sum of the standard scores on the three midterms and final examination. The experimental group had the higher $A_t$ total but the difference was not significant. However, the difference approached significance at the 9 per cent level for one of the instructor's classes. The control group had the higher $A_t$ total for the other instructor. This difference approached significance at the 20 per cent level. A two-way analysis of covariance was used on the $A_t$ variable. The variables were instructor and treatment. The covariates were ACT scores in mathematics and quality points. Neither of the variables was significant. They both had F scores less than 0.25. An
interaction between the two variables had a F score of 1.79 but was not significant at the 0.10 level. The two covariates considered individually or jointly were significant at the 1 per cent level. The group with the higher achievement had the lower attitude toward mathematics; so a positive correlation between achievement in mathematics and attitude in mathematics was not found.

**Study Habits**

The two groups have similar perceptions about their study habits. No change in any particular study habit can be attributed to either treatment. The changes appeared to be somewhat independent of the instructor or treatment variable. Perceptions of study habits appear to be set before the students begin their college mathematics courses.

**LIMITATIONS**

The preceding research findings should be interpreted with the following limitations of the study in mind:

**Randomization**

Because it was not possible to randomly assign subjects to treatments, it is possible that the groups were not initially equivalent with respect to variables which conceivably could have biased the outcomes of the
experiment. One such variable was class standing since 72.7 per cent of the subjects were freshmen. Another such variable was sex since the subjects were predominately (85.5 per cent) male. Other variables were I. Q. and measures of previous academic achievement.

Homogeneity of Students

In a self-study by The Ohio State University Lima Campus for a North Central Accrediting Committee visit in February, 1972, it was reported that the students on campus were homogeneous with respect to educational, cultural, and environmental experiences. Many of the students knew some others prior to coming to college. It is quite possible that students in different treatment classes may have shared ideas or material. However, on a questionnaire the students answered that they did not study together. Therefore, it is believed that no extreme bias was introduced.

Course Content

Many of the students had studied algebra and trigonometry in high school. Functions were used as a vehicle to teach the content of the Mathematics 150 course. It may have been difficult for some of the students to learn or relearn the material by a different approach.

Instruments

The A_c instrument was not standardized. Its
reliability coefficients on the Kuder-Richardson Form 20 and 21 were respectively 0.644 and 0.538. The mathematics study habits questionnaire was not standardized. A reliability coefficient was determined a split halves coefficient and the Spearman-Brown Prophecy Formula. The split halves coefficient was 0.720 and the derived correlation coefficient was 0.837.

Any conclusions about this study with respect to achievement \( A_c \) or \( A_L \) and/or with respect to study habits should take into consideration the limitations of the instruments and examinations.

RECOMMENDATIONS

The recommendations which are put forth in this section are based on the investigator's experiences in conducting the pilot study, this present study, and an analysis of the results of the studies. The recommendations are of two types: recommendations for further research, and recommendations for educational practice.

Recommendations For Further Research

1. The mathematics study habits questionnaire should be refined so that greater validity and reliability result.

2. Replications of this study in mathematics and other disciplines, at this and other institutions, should be conducted to test the generalizability of the results and conclusions of this study.
3. Modifications of the experimental treatments should be attempted in other experimental studies. The experimental treatments used in this study assigned newly-created exercises on every section. This averaged more than one assignment a day. This type of endeavor is time consuming and mentally taxing. Therefore, the investigator suggests modifications in the creation and distribution of homework assignments. These suggestions are to try specially prepared materials
   a) two times a week
   b) once a week
   c) once every two weeks
   d) once prior to every examination

4. Replications of this study or modified studies should be conducted at various grade levels.

5. Replications of this study should be conducted in the elementary grades, which are thought to be critical times for the formation of attitudes and study habits. Studies at the lower level might help to determine if higher initial attitudes and better beginning study habits can be developed through the use of homework assignments.

6. Research for longer periods of time should be conducted. This research might use the experimental treatment for the duration of the study or use a crossover approach of using the experimental treatment for part of the time and a control treatment part of the time.
Some of the results of the pilot study and this study seemed to be more dependent on the type of course than on the treatments involved. One result was attitude toward mathematics. In the pilot study, the attitude of the groups increased; in this study the attitudes of the groups decreased. In the author's experience of teaching the Math 150 and Math 105 courses on both the Columbus and Lima campuses, he observed that the attitudes of the Math 105 students seemed to increase during the quarter, while the attitudes of the Math 150 students did not appear to increase during the quarter. The results of this study support this observation. A partial explanation of this observation may be that the Math 105 course is a review of arithmetic with emphasis on unifying concepts while Math 150 contains both new content and new concepts. Also there may be some changes in attitude and achievement that are associated with a transition from high school mathematics to college mathematics.

7. The effects of the type of content of a course upon attitude and achievement should be investigated.

8. The effects of taking college mathematics as compared with taking high school mathematics upon attitude and achievement should be investigated.

The results of this study and those of Peterson (50) and Laing (34) seem to say that types and characteristics of homework are important. They seem to indicate that there are several different aspects of homework that might
singly or collectively affect the mathematics education of students.

9. Homework studies should focus on types and characteristics of homework rather than on whether to have homework or not have homework.

10. The four characteristics of the personalized homework (test-like questions, consolidation of problems and answers, references from students' environment, and built in review of each week's work) should be tested singly in homework studies for effects on achievement and attitude.

Recommendations For Educational Practice

Any generalizations based on the findings of this study must take into account the limitations of the study. With these limitations in mind, it is the experimenter's opinion that, pending further research such as that suggested above, the following are valid recommendations for educational practice:

1. Teachers of mathematics should assign some teacher-designed homework exercises which have been personalized.

2. Teachers should design homework questions to test the key concepts of the material, to require the students to think about the concepts, and to encourage the students to ask questions about the concepts of the material.
3. Textbook authors and publishers should incorporate different formats of homework assignments in their textbooks. The authors should group problems that cover the content into sets of assignments and use different formats in presenting the problems within the various sets rather than list a set of uniformly stated problems at the end of a section or chapter.
APPENDIX A

SYLLABII FOR THE MATHEMATICS 150 COURSE
<table>
<thead>
<tr>
<th>Day</th>
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<th>Section(s)</th>
<th>Homework</th>
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APPENDIX B

PERSONALIZED HOMEWORK PROBLEMS
Assignment 1 Integers

1. Calculate each of the following:
   a) $6 + (-8) - (4-5)(7-9)$
   b) $-\left[\frac{2-3(3-5)}{2-(6+2)}\right]
   c) $76^2 - 24^2$
   d) $51^3 - 50^3$

   answers  
   a) $-4$
   c) $5200$

2. Express (in simplified form) the negatives of the following:
   a) $-6$
   b) $-(-y)$
   c) $(-x)^2$
   d) $-x^2$
   e) $x-(y-z)$
   f) $3a-\left[2b+(2-a)\right]$

   answers  
   a) $6$
   c) $-x^2$
   e) $-x+y-z$

3. Which of the following have positive negatives?
   a) 5  
   b) -6  
   c) -a  
   d) all negative integers

   answers  
   b, d

4. Simplify the following:
   a) $-3(a-1)-\left[2a-(3a-2)\right]$
   b) $-\left[\frac{3x-2(2x-3)}{3}\right]$
   c) $(3a+2)^2 - (3a-2)^2$ Hint: $x^2 - y^2 = (x+y)(x-y)$

   answers  
   a) $1-2a$
   b) $x-6$
   c) $24a$
Assignment 1 page 2

5. Find the following products.
   a) \((a+b)(a^2-ab+b^2)\)  
   b) \((a-2)(a+1)(a-1)\)  
   c) \((2x-y)^3\)  
   d) \((a-b+c)(a-b-c)\)

   answers  
   a) \(a^3 + b^3\)  
   c) \(8x^3 - 12x^2y + 6xy^2 - y^3\)

6. Factor the following.
   a) \(x^3 + z^3\)  
   b) \(4a^3 - 16dg^2\)  
   c) \(27x^3 - \frac{8}{y^3}\)  
   d) \(48b^2 + 24bc - 40c^2\)

   answers  
   a) \((x+z)(x^2-xz+z^2)\)  
   c) \((3x - \frac{2}{y})(9x^2 + \frac{6x}{y} + \frac{4}{y^2})\)

7. Prove that the equation \((x-y)-z = x-(y-z)\) is not one of the laws of arithmetic.

8. Show that the operation \(*\) defined by \(a*b = 0\) for any two numbers \(a\) and \(b\) obeys the following laws of arithmetic.
   a) \(a*b = b*a\)
   b) \(a*(bc) = (a*b)(a*c)\)

9. Which of the laws in problem 8 does the operation \(*\) defined by \(a*b = 1\) obey?
Assignment 2  The Rational Numbers

1. Explain why each of the following is a rational number.
   a) 19   b) .19   c) .3333...   d) .157157...

   answers a) all integers are rational numbers
             c) it is the decimal equivalent of 1/3

2. Use rules to show that
   a) $\frac{a}{b} = -\frac{a}{b}$
   b) $\frac{a}{-b} = -\frac{a}{b}$

3. Simplify the following.
   a) $\frac{ax + az - bx - bz}{ay - by - aw + bw}$
   b) $\frac{a - \frac{1}{a}}{a^2}$
   c) $1 - \frac{1}{1 - \frac{1}{y}}$

   answers a) $\frac{x+z}{y-w}$
             c) $\frac{-1}{y-1}$

4. Find the reciprocal of each of the following and simplify your result.
   a) $a+b$
   b) $\frac{1}{a} + \frac{1}{b}$

   answers a) $\frac{1}{a+b}$
             b) $\frac{ab}{a+b}$

5. Perform the operations and simplify the result of the following.
   a) $\frac{a^2 - y^2}{a^3 - y^2} \cdot \frac{a+y}{a}$
   b) $\frac{2}{12x^2 - 3} + \frac{3}{2x - 4x^2}$
   c) $\frac{2s - 1}{4} + \frac{s + 2}{3s - 12}$
   d) $\frac{w + z}{x} - \left( \frac{w}{x} + \frac{z}{x} \right)$
5. (continued).

\[ e) \quad 16 - \frac{1}{x^2} - \frac{1}{x^2} - \frac{1}{x^2} \]

\[ f) \quad x^2 + 2 + \frac{1}{x^2} - \frac{1}{x^2} \]

**Answers**

\[ a) \quad \frac{a}{a^2 + ay + y^2} \quad b) \quad \frac{-14x - 9}{6x(2x + 1)(2x - 1)} \]

\[ c) \quad \frac{-5(s + 1)}{5(s - 4)} \quad d) \quad 0 \]

6. Are there any values of \( a \) for which \( \frac{a^2 - 4}{a - 2} \) is not equal to \( a + 2 \)?

**Answer**

Yes, \( a \) cannot be equal to 2.

7. Let \( a \neq 0 \). \( a/0 \) is not defined. Does \( 0/a \) represent a number?

**Answer**

Yes, \( 0/a = 0 \) if \( a \neq 0 \).

8. If \( a \neq 0 \), find

a) the reciprocal of the reciprocal of \( a \)

b) the negative of the negative of \( a \)
Assignment 3 The Real Numbers

1. All rational numbers can be expressed either as terminating or repeating nonterminating decimals.
2.425131313... repeats in a block(13) and so is a rational number. .23 terminates and is a rational number. .23 = .230000... therefore terminating decimals can be thought of as repeating nonterminating decimals with a zero repeating. Show by dividing that \( \frac{2}{7} \) and \( \frac{19}{5} \) fit into one of the above categories.

2. If \( a = .181818... \)(repeating), then \( 100a = 18.181818... \)
Therefore \( 100a - a = 18.181818... - .181818... \) or
\[ 99a = 18 \]
Thus \( a = \frac{18}{99} = \frac{2}{11} \) Use this method to express
\[ b = .142142... \] and \( c = 2.9999... \) as fractions.

answers \( b = \frac{142}{999} \quad c = \frac{3}{1} = 3 \)

3. Circle the correct choice in the following.
a) The sum of two rational numbers is (always, sometimes, never) rational.
b) The sum of two irrational numbers is (always, sometimes, never) irrational.
c) The sum of a rational and an irrational number is (always, sometimes, never) rational.

answers a) always b) sometimes c) never

4. Replace the word "sum" with the word "product" in the preceding question and answer the parts.

answers a) always b) sometimes c) sometimes

5. Is there a smallest positive integer? Is there a smallest positive rational number?

answers Yes, 1 No
Assignment 4 The Order Relation

1. Insert in the blank the symbol (\(<\), \(=\), \(>)\) that makes the following true.
   a) \(-5 \_ _ \_ -2\)
   b) \((-3)(-5) \_ _ 15\)
   c) \(-2-(4-6)\)
   d) \(27/57 \_ _ 62/119\)
   e) \(-5/3 \_ _ -1.6 \_ _ 0\)
   f) \(\sqrt{7} \_ _ 2.646\)
   g) \(\frac{4+\sqrt{2}}{2} \_ _ \frac{9}{5}\)
   h) \(11/2 \_ _ \pi/2\)
   i) \(.49999... \_ _ 1/2\)

   answers  a) \(<\)  c) \(<\)  e) \(<\)  g) \(>\)

2. Prove that if \(a < b < 0\), then \(a^2 > b^2\). Is the converse true?

3. Prove that the sum of a positive number and its reciprocal is never less than 2.

4. The current in a certain stream is 2 miles per hour.
   a) If a man has a motor boat that goes 5 miles per hour in still water, how far can he travel and still return in 3 hours.

   b) Another man takes his motor boat to a point 20 miles downstream and back in less than 4 hours. How fast can the boat travel in still water?

   answers  a) 6.3 miles
5. a) Show that if \( x \) and \( y \) are two numbers such that 
\[ x + y = 12, \text{ then } xy \leq 36 \]

b) Show that if \( xy = 9 \) and \( x \) and \( y \) are both positive, 
then \( x + y \geq 6 \)

6. Discuss the following "solution" to the problem:
Find a number \( x \) such that \( 16 - 4x < 4 - x \).

1) Factor 
\[ 4(4-x) < 4-x \]

2) Divide by \( 4-x \) 
\[ 4 < 1 \]

This is a false conclusion and so there is no solution to the original inequality.
Assignment 5  Sets

1. Place the number of the expression in the column to the right in front of the expression to the left to which it is equal.

   a) ____ A U (B \lor C)  
   1) A \land B 

   b) ____ (A \land B) U (A \lor C)  
   2) (A \land B) \land C 

   c) ____ B \lor A  
   3) A \land (B \lor C) 

   d) ____ A U B  
   4) A U (B \lor C) 

   e) ____ A \land (B \lor C)  
   5) B U A 

   f) ____ (A U B) U C  
   6) (A U B) \land (A U C) 

   answers  a) 6  b) 3 

2. Show that if B \subseteq A, then A U B = A and A \land B = B

3. Is it true that if A \land B = A or if A U B = B, then A \subseteq B ?

4. Use only one pair of braces to express the following sets.

   a) \{x>2\} U \{x<6\}  
   b) \{x>3\} \land \{x<8\} 

   c) \{x<-5\} U \{x>3\}  
   d) \{x<-5\} \land \{x>3\} 

   e) ((\{x<5\} U \{x+5=0\}) \land \{x>1\})  
   f) \{3x+2<11\} \land \{x+2<-4\} 

   answers  a) \{2 < x < 6\}  c) \{x/ x<-5 \text{ or } x>3\} 
              d) {} 

5. Illustrate each solution in the preceding problem as collections of points of the number scale.
6. Solve the following inequalities.

a) \( 3x + 2 > 7 \)

b) \( x + 5 < 7 - 2x \)

c) \( 5 - 2x > 4 - x \)

d) \( 6x - 5 > 2x + 7 \)

e) \( 3x + 4 < 5x - 2 \)

f) \( \frac{1}{3}x - \frac{7}{2} \geq 4 \)

g) \( \frac{2}{x} + 4 < \frac{3}{x} + 2 \)

h) \( 7 < 3x < x + 6 \)

i) \( x + 1 < 2x - 3 < 5 + x \)

7. Show that \(-1, 2 \subseteq \{x^5 - x^4 - x^2 - 4x^2 + x + 6 = 0\} \)
Assignment 6  Solving Inequalities

1. Select the correct solution set for the following.

a) \( x(x-1) < 0 \)
   1) \( \{x < 0\} \)
   2) \( \{x < 1\} \)
   3) \( \{0 < x < 1\} \)
   4) \( \{-1 < x < 1\} \)
   5) NOT (none of these)

b) \( x^2 - x < 2 \)
   1) \( \{x > 2\} \cup \{x < -1\} \)
   2) \( \{-1 < x < 2\} \)
   3) \( \{x > 2\} \cup \{x < 0\} \)
   4) \( \{x < 2\} \)
   5) NOT

c) \( x^5 - x^3 > 0 \)
   1) \( \{x < 1\} \)
   2) \( \{-1 < x < 0\} \cup \{x > 1\} \)
   3) \( \{0 < x < 1\} \)
   4) \( \{x < 0\} \)
   5) NOT

d) \( (x-2)(x+1) < (x+1)^2 \)
   1) all reals
   2) \( \{x < 2\} \)
   3) \( \{-1 < x < 2\} \)
   4) \( \{x < -1\} \)
   5) NOT

e) \( x^2 - 5x > 6 \)
   1) \( \{x < 6\} \)
   2) \( \{-1 < x < 0\} \cup \{x > 6\} \)
   3) \( \{-5 < x < 6\} \)
   4) \( \{x < 1\} \)
   5) NOT

f) \( \frac{x-2}{x+2} \leq 3 \)
   1) \( \{x \geq -2\} \)
   2) \( \{-4 < x \leq -2\} \)
   3) \( \{-4\} \)
   4) \( \{x > -2\} \cup \{x \leq -4\} \)
   5) NOT

g) \( \frac{x^2+9}{6x} \leq 1 \)
   1) \( \{x < 0\} \)
   2) \( \{0 \leq x < 3\} \)
   3) \( \{x \geq 3\} \)
   4) \( \{x = 3\} \cup \{x < 0\} \)
   5) NOT
2. The complement $cA$ of a set of real numbers is the set of real numbers that are not contained in $A$. For example $cQ$ (where $Q$ is the set of rational numbers) is the set of irrational numbers.

Check the validity of the following rules.

a) If $A \subseteq B$, then $cB \subseteq cA$

b) $c(cB) = B$

c) $c(A \cap B) = cA \cup cB$

d) $c(A \cup B) = cA \cap cB$

3. Find the following sets.

a) $c\{x/ x \geq b\}$

b) $cR^1$

c) $c\{x/ a(x \leq b)\}$

d) $c\{x/ A(x) \leq B(x)\}$

e) $c\{x/ x^2 \neq a^2\}$

4. Show that

$$\{x/ (x-a)(x-b)\} = \{x/ x > \text{larger of } a \text{ and } b\} \cup \{x/ x < \text{smaller of } a \text{ and } b\}$$

Is the equation still valid if $a = b$?
Assignment 7   Absolute Value

1. Solve the following equations.
   a) \(|x| = 8\)  b) \(|x| = 3.6\)  c) \(|x| = -3\)
   d) \(|x| = |-4|\)  e) \(|3x| = 9\)  f) \(3|x| = 9\)

   answers    a) \{-8,8\}  c) \{0\}  e) \{-3,3\}

2. Select the best answer for each of the following.
   a) \(|3x| = 3x\)  1) all \(x\)  2) \(x>0\)  3) \(x<0\)
      4) \(x = 0\)  5) NOT
   b) \(|3x| = 6x\)  1) \(\emptyset\)  2) \(x>0\)  3) \(x<0\)  4) \(x=0\)  5) NOT
   c) \(|x-\frac{1}{2}| = \frac{5}{2}\)  1) \{3,-2\}  2) \(x \leq 3\)  3) \(x=3\)
      4) \(x=\frac{5\pm 1}{2}\)  5) NOT
   d) \(|x-2| = |2-x|\)  1) \{2\}  2) \(|x \leq -2|\)  3) \(|x \geq 2|\)
      4) \(|x \leq x+2|\)  5) NOT
   e) \(|x-3| = |x| - 3\)  1) \(|x \geq 0|\)  2) \(|x \leq 3|\)  3) \(|x \geq 3|\)  4) \(3\)  5) NOT

   answers    a) 5  c) 1

3. Given that \(|x-1| = 4\), find
   a) \(|x|\)  b) \(|x+2|\)  c) \(|x-3|\)  d) \(|x+5|\)

   answers    a) \{3,5\}  c) \{6,2\}

4. Show that \(|a| < 1\) if and only if \(a^2 < 1\).

5. Compare \(x\) and \(-x\). Which is larger? How does \(|x|\) compare with \(x\) or \(-x\)?

6. Show that \(|y| \geq |x|\) if and only if \(|y| \geq x\) and \(|y| \geq -x\).
Assignment 8  Inequalities involving Absolute values

1. Express the following without using absolute value.

a) \(|4x| < 3\)  b) \(|\frac{x}{4}| < 3\)  c) \(|x+2| < 5\)

d) \(|x-3| < 8\)  e) \(|3-x| < 2\)  f) \(|2x-6| \leq 4\)

g) \(|x - \frac{2}{3}| \leq \frac{1}{2}\)  h) \(\left|\frac{2x^2 - x}{x}\right| \leq 4\)  i) \(|x^3| \leq x^2\)

j) \(x^3 \leq |x^2|\)  k) \(\{3x > 4\}\)  l) \(\{\left|\frac{1}{2}x\right| > 2\}\)

m) \(|x-3| > 6\)  n) \(|3x-5| \geq 4\)  o) \(|x-\frac{2}{3}| \geq \frac{3}{2}\)

p) \(|3x-2| \leq 4\)

answers  a) \(-\frac{3}{4} < x < \frac{3}{4}\)  c) \(-7 < x < 3\)  e) \(1 < x < 5\)

g) \(\frac{1}{6} \leq x \leq \frac{7}{6}\)  i) \(-1 \leq x \leq 1\)  k) \(x > \frac{4}{3}\) or \(x < \frac{-4}{3}\)

m) \(x > 9\) or \(x < -3\)  o) \(x > \frac{13}{6}\) or \(x < \frac{-5}{6}\)
2. Solve the following sets of inequalities and sketch the solutions as sets of points on the number line.

   a) \{ |x-2| \leq |x| + 2 \}  
   b) \{ |x-2| \leq |x-1| \}  
   c) \{ |x-1| < |x| \}  
   d) \{ |x-2| < 1 \}  
   e) \{ |x+2| \leq 3 \}  
   f) \{ |2x-5| \geq 3 \}

   answers  a) \mathbb{R}^1  
   b) \{ x \geq \frac{3}{2} \}  
   c) \{ x > \frac{1}{2} \} 

3. Express each of the following inequalities as a single inequality involving an absolute value.

   a) \ 3 < x < 7  
   b) \ -4 \leq x \leq 2 
   c) \ 1 < 2x+1 < 7  
   d) \ 3 < 1-2x < 7 
   e) \ -2 < 3x+1 < \frac{7}{2}  
   f) \ -3 < 1-4x < \frac{3}{2} 

   answers  a) \ |x-5| < 2  
           c) \ |2x-3| < 3  
           e) \ |3x+ \frac{1}{4}| < \frac{11}{4} \
4. Solve the following inequalities.

a) 3|x| + 4 < 5|x| - 3

b) |x^2 - 13| < 12

c) \[ \left| \frac{1}{x} - 4 \right| < 2 \]

d) \[ \left| \frac{1}{x} - 4 \right| > 1 \]

e) \[ |x^2| < 9 \]

Answers:

a) \( x > \frac{7}{2} \) or \( x < -\frac{7}{2} \)

b) \(-5 < x < -1 \) or \(1 < x < 5 \)

c) \( \frac{1}{6} < x < \frac{1}{2} \)

d) \( x < 0 \) or \( 0 < x < \frac{1}{5} \)

e) \(-3 < x < 3 \)
Assignment 9 page 3

7. If we had defined $a^0 = 0$ for $a \neq 0$, which of the following rules would be valid?

a) $a^m a^n = a^{m+n}$  
b) $(a^m)^n = a^{mn}$  
c) $(ab)^n = a^n b^n$  
d) $(\frac{a}{b})^n = \frac{a^n}{b^n}$  
e) $\frac{a^n}{a^m} = \begin{cases} a^{n-m} & (n>m) \\ 1 & (n=m) \\ \frac{1}{a^{m-n}} & (n<m) \end{cases}$

answers  b) if $m$ and $n$ are not both zero  and c)

8. Multiple Choice

a) If $\frac{2}{3} x + \frac{1}{2} < \frac{2}{7} x + 1$, then

1) $x < 2$  
2) $x > -3$  
3) $x < \frac{15}{8}$  
4) $x < \frac{1}{6}$  
5) NOT

b) $\frac{x-2}{x+2} > 0$ has solution set  
1) $x > 2$  
2) $x > -3$  
3) $(x > 2) \cap (x > -3)$  
4) $(x > 2) \cup (x < -3)$  
5) NOT

c) The solution set of $|x+2| = |x| + 2$ is

1) $x \geq 0$  
2) $x \leq 2$  
3) $x \geq -2$  
4) $R^1$  
5) NOT

d) If $|x^2 - 7x - 4| < 4$, then

1) $\{-1 < x < 0\} \cup \{7 < x < 8\}$  
2) $-1 < x < 8$  
3) $x > 4$  
4) $0 < x < 7$  
5) NOT is the solution.

e) $(x^2 - 3)(x^{-1} - y^2) = \begin{cases} 1 & x \neq y^{-3} \\ 2 & x = y \end{cases}$

answers  a) 1  b) 4  c) 1  d) 1  e) 2
answers  a) 13/36  b) (x+y)/xy  c) 1/(1-b)  d) x-2

4. Express each of the following without positive exponents
a) $a^2 - \frac{1}{b^2}$  
   b) $(\frac{a}{b})^2$  
   c) $x^2 + y^2$

answers  a) $\frac{1}{a^2} - b^{-2}$  
   b) $(z/2)^{-2}$  
   c) $\frac{1}{x^2} + \frac{1}{(y^2)}$

5. Which of the following pairs are identical?
   a) $xy^{-3}$ and $yx^{-3}$  
   b) $2 + y^{-1}$ and $\frac{1}{x+y}$

6. Solve the following inequalities.
   a) $|x-2| < 2^{-1}$  
   b) $x - 3^{-2} < 3^{-1}x + 2$

   c) $|x|^{-1} < (-1)^{-2}$  
   d) $|x|^{-1} > 2^{-1}$

   e) $(2x-3)^0 \leq x+3$  
   f) $x - 4x^{-1} < 3$

answers  a) $\frac{3}{2}(x\frac{5}{2})$  
   c) $x \geq 1$ or $x < -1$  
   e) $-2 \leq x(\frac{3}{2}$ or $x > \frac{3}{2}$
Assignment 9  Exponents

1. Multiple Choice
a) \((-3)^{-2} = 1) 6 \hspace{1cm} 2) \frac{1}{9} \hspace{1cm} 3) \frac{1}{9} \hspace{1cm} 4) 9 \hspace{1cm} 5) NOT\)
b) \(-3^{-2} = 1) -6 \hspace{1cm} 2) \frac{1}{9} \hspace{1cm} 3) -\frac{1}{9} \hspace{1cm} 4) -9 \hspace{1cm} 5) NOT\)
c) \(\frac{-2}{5-1} = 1) -10 \hspace{1cm} 2) \frac{2}{3} \hspace{1cm} 3) -2\frac{5}{3} \hspace{1cm} 4) -\frac{2}{5} \hspace{1cm} 5) NOT\)
d) \((x^{-3})^2 = 1) x^{-\frac{3}{2}} \hspace{1cm} 2) x^{-5} \hspace{1cm} 3) x^{3/2} \hspace{1cm} 4) x^6 \hspace{1cm} 5) NOT\)

Answers:
- a) 3
- b) 3
- c) 1
- d) 4

2. Simplify the following expressions.
   a) \(\left(\frac{3}{4}\right)^2 (\frac{a}{3})^0\)
   b) \((x^3 y^{-2} z)^2 (x^2 y z^3)^{-3}\)
   c) \(\frac{3ab^{-3}}{5a^{-2}b}\)
   d) \(\frac{(2a^{-2})^3}{a^2}\)
   e) \((a^{-3})^2 -1\)
   f) \(\frac{r^{-3} s^2}{r^{-5} s^{-1}} -2\)

Answers:
- a) 9/16
- e) \(a^6\)

3. Simplify the following (eliminate all zero and negative exponents)
   a) \(4^{-1} + 3^{-2}\)
   b) \(x^{-1} + y^{-1}\)
   c) \((a^0 - b)^{-1}\)
   d) \((x^2 - 4)(x + 2)^{-1}\)
   e) \(a^3 b^2 (b^{-1} + a^{-2})\)
Assignment 10

Radicals and Rational Exponents

1. Matching

   a) $8^{2/3}$  
   b) $16^{3/2}$  
   c) $-27^{2/3}$  
   d) $64^{-5/6}$  
   e) $-32^{-2/5}$  
   f) $(-64)^{4/3}$  
   g) $(1024)^{7/6}$

1) $1/32$  
2) $-18$  
3) $-1/4$  
4) $4$  
5) $128$  
6) $64$  
7) $-256$  
8) $24$  
9) $-9$  
10) $256$  
11) $1/4$

   answers  a) 4  c) 9  e) 3  f) 10  12) NOT

2. Multiple Choice

   a) $(x^{2/3})^{-3/4} = 1) x^{-1/9}  2) \sqrt[9]{x}  3) \sqrt[3]{x^2}$

        4) $x^{2/3} / x^{3/4}  5) NOT$

   b) $(a^2 - 4ab + 4b^2)^{1/2} = 1) a-2\sqrt{a^2+2b}  2) a+2b$

        3) a-2b  4) $|a-2b|$  5) NOT

   c) $\sqrt[3]{x/y} = 1) \sqrt[3]{x/y}^{-1}  2) x^{1/3}y^{-1/3}  3) (xy)^{-1/3}$

        4) $x^{-1/3}y^{3}  5) NOT$

   d) $\frac{1}{x^{1/2} - y^{1/2}} = 1) \sqrt[2]{y}/\sqrt[2]{x}  2) \frac{x+y}{\sqrt{x} - \sqrt{y}}$

        3) $\frac{\sqrt{x} + \sqrt{y}}{x - y}  4) x^{-1/2} - y^{-1/2}  5) NOT$
2e) \[ \sqrt[4]{x^2} \sqrt{y^2 - 1} = \]
1) \( |x|^{1/2} x^{2/5} y^{-1/5} \)
2) \( x^{9/10} y^{-1/5} \)
3) \( |x|^{1/2} x^{2/5} y^{-1/5} \)
4) \( x^{-1/2} x^{2/5} y^{-1/5} \)
5) NOT

f) \[ \sqrt[3]{-x^3} \]
1) \( 1/x^{2/3} \)
2) \( -1/x^{3/2} \)
3) \( -x^{3/2} \)
4) \( 1/x^{1/3} \)
5) NOT

g) \[ \sqrt[4]{x^3} \]
1) \( 4^{x^{-9}} \)
2) \( x^{-9/8} \)
3) \( x^{-3/4} \)
4) \( x^2 \sqrt[4]{x^{-1}} \)
5) NOT

answers: a) 2  b) 4  c) 2  d) 3  e) 1  f) 5

3. Multiple Choice
a) \[ \frac{\sqrt{6} - 3}{\sqrt{6} + 3} = \]
1) \( \sqrt{3}/3 \)
2) \( -\sqrt{3}/9 \)
3) \( 5 - 2\sqrt{6} \)
4) \( 2\sqrt{6} - 5 \)
5) NOT

b) \[ \frac{6 + \sqrt{5}}{6 - \sqrt{5}} = \]
1) \( \sqrt{11} \)
2) \( \sqrt{41}/31 \)
3) \( (61 + 12\sqrt{5})/31 \)
4) \( (6\sqrt{11} + \sqrt{55})/11 \)
5) NOT

answers: a) 4
Assignment 11: Functions in General

1. Multiple Choice (Finding the domains of functions).
   a) $f(x) = \frac{1}{3x^2 + 2}$, $D_f = 1) \mathbb{R} \quad 2) (0, \infty) \quad 3) x \neq 0 \quad 4) (-2/3, \infty) \quad 5) \text{NOT}$
   b) $g(x) = \sqrt{1/(x-1)}$, $D_g = 1) x \neq 1 \quad 2) (1, \infty) \quad 3) (-\infty, \infty) \quad 4) (1,6) \quad 5) \text{NOT}$
   c) $h(x) = \frac{1}{x}$, $D_h = 1) (-\infty, 0) \cup (0, \infty) \quad 2) (0, \infty) \quad 3) \text{NOT}$
   d) $f(x) = \sqrt{(x+2)^2}$, $D_f = 1) \mathbb{R} \quad 2) (-\infty, -2) \cup (-2, \infty) \quad 3) \text{NOT}$
   e) $g(t) = \frac{t}{|t|}$, $D_g = 1) (-\infty, 0) \cup (0, \infty) \quad 2) (0, \infty) \quad 3) \text{NOT}$
   f) $h(y) = \sqrt{y/(y+3)}$, $D_h = 1) [0, \infty) \quad 2) (-3, 0] \quad 3) \text{NOT}$

   g) If your answer to any of the above was 5), find the correct domain.
   answers a) 5 b) 2 e) 4 g) f), $(-\infty, -3) \cup [0, \infty)$

2. $D_f$, the domain of $f$, is $\{1,3,6\}$; find $R_f$, the range of $f$.
   a) $f = \{(x,3)\}$, $R_f = 1) \{3\} \quad 2) [(1,3),(3,3),(6,3)] \quad 3) \text{NOT}$
   b) $f = \{(x,2x+3)\}$, $R_f = 1) \{1,3,6\} \quad 2) \{(x,\frac{x-3}{2})\} \quad 3) \text{NOT}$
   c) $f = \{(x,|3-x|)\}$, $R_f = 1) [-2,0,3] \quad 2) \{(x,|x-3|)\} \quad 3) \text{NOT}$

   answers a) 1 b) 3 c) 4
3. If \( G(x) = 2x - 3 \), find:
   a) \( G(2) \)
   b) \( 5G(2) \)
   c) \( G(x^2) \)
   d) \( G(2\sqrt{3}) \)
   e) \( G(t+3) \)
   f) \( \sqrt{G(\sqrt{2}) + 3} \)

4. Place the \( x \in \{<, >, =\} \) that makes the following true.
   \( f(x) = x^2 - 2 \)
   a) \( f(4) - f(2) \quad \underline{<} \quad f(4-2) \)
   b) \( f(1/3) \quad \underline{<} \quad 1/f(3) \)
   c) \( (f(3))^2 - f(2) \quad \underline{=} \quad f(f(3)) \)

   answers  \( a) > \quad b) \ < \quad c) = \)

5. State that the following sets are functions or explain why they are not.
   a) \( \{(x,y)/ y^2 = x^2\} \)
   b) \( \{(x,y)/ |x| + y = 1\} \)

   answers  \( a) \) Not a function; a domain element may be paired with two range elements. \((2,2)\) and \((2,-2)\) for example.
   \( b) \) Function
Assignment 12    Examples of Functions

1. If $f(x) = 2|x| - x$, then
   a) $f(-2) =$
      1) 2  2) 6  3) -2  4) -6  5) NOT
   b) $f(\frac{2}{3}) =$
      1) $\frac{2}{3}$  2) 1  3) -1  4) $\frac{4}{3}$  5) NOT
   c) $f(\sqrt{3}) =$
      1) $\frac{3}{\sqrt{2}}$  2) 3  3) $3\sqrt{3}$  4) $\sqrt{3}$  5) NOT

answers a) 2   b) 1   c) 4

2. Let $f(x) = |x|$
   Which of the following are true for all $x \in \mathbb{R}$?
   a) $f(x^2) = (f(x))^2$
   b) $f(x) < x + 2$
   c) $f(|x|) = |f(x)|$

3. A ship is sailing due west at 15 knots. At 5 p.m. a Coast Guard Station is sighted 3 miles directly north of the ship. Let $d$ be the distance between the Station and the ship $h$ hours later. The formula that expresses $d$ in terms of $h$ is:
   1) $d = 15h + 3$
   2) $d = \sqrt{15h + 3}$
   3) $d = \sqrt{25h^2 + 1}$
   4) $d = \sqrt{(15h)^2 - 9}$  5) NOT

4. A snowball is melting at a rate that decreases its radius 1 inch per hour.
   a) If the ball has a radius of 30 inches at a certain time, the formula for its volume, $V$ cubic inches, $t$ minutes later is:
      1) $\frac{4}{3}\pi(30-t)^3$
      2) $\frac{4}{3}\pi(30-60t)^3$
      3) $\frac{4}{3}\pi(30t)^3$
      4) $\frac{4}{3}\pi(30-\frac{t}{60})^3$  5) NOT
4b) The domain of the Volume function in a) is:
1) (0,1800]  2) (0,3]  3) (0,∞)  4) (30,∞)  5) NOT

5. An open box is to be made from a rectangular piece of tin 8 inches by 6 inches by cutting pieces s inches square from each corner and bending up the sides.

a) The formula for the volume, V cubic inches, of the box in terms of s is:
1) s^3 - 48  2) 48s - 14s^2 + s^3  3) s(8 - s)(6 - s)
4) 4s(12 - 7s + s^2)  5) NOT

b) The domain of the volume function in a) is:
1) (0,8)  2) (0,6)  3) (0,3)  4) (0,4)  5) NOT

answers    a) 4   b) 3

6. A closed box, with a square base x by x, is to be made of material costing 50¢ per square foot for the sides and 80¢ per square foot for the bottom. Find a simplified formula for the cost C in terms of x if the box is to have a volume of 20 cubic feet.
Assignment 13  Cartesian Coordinates and The Distance Formula

1. Use the map on the next page to find:

   a) The coordinates of A, B, C, D, E, and F.

   b) AB, CD, EF

   c) The lengths of the sides of the triangle formed by the front entrances of the three buildings on campus.

   answers  b) $\sqrt{29}$  $2\sqrt{13}$  5

2. The distance between two points $P_1$ and $P_2$ is denoted by $P_1P_2$ or $d(P_1P_2)$.

   a) $P_1$ has coordinates $(x-y,x+y)$, $P_2 (y+x,y-x)$: $d(P_1P_2) =$
      1) $\sqrt{2x^2 - 2y^2}$  2) $2\sqrt{x^2 + y^2}$  3) $2(x-y)$  4) $\sqrt{2(x+y)}$
      5) NOT

   b) The distance between $(x^{1/2},y^{1/2})$ and $(-x^{1/2},y^{1/2})$ is:
      1) $2\sqrt{x+y}$  2) $\sqrt{2x+2y}$  3) $\sqrt{2x-2y}$  4) $\sqrt{4x-4y}$  5) NOT

   c) $P_5$ has coordinates $(1-s^2)$, $P_6 (1+s^2,s^3)$ : $P_5P_6 =$
      1) $\sqrt{4+(s-s^3)^2}$  2) $|s|(s^2+1)$  3) $\sqrt{6s^2 + 6s^4 + s^2}$
      4) $\sqrt{s^4 + 2s^2 + 1}$  5) NOT

   answers  a) 2  b) 1  c) 2

3. The coordinates of three stakes on the soccer field are (2,3), (8,9) and (12,-7). Mr. Parete claims that these stakes determine a right triangle. Use the distance formula to test his claim.
MAP
of the
LIMA CAMPUS

MUMAUGH ROAD
CAMPUS DRIVE

PARKING
PARKING

GALVIN HALL
TECHNICAL EDUCATION LABORATORY

STUDENT ACTIVITIES BUILDING

PARKING

U. S. 30S
4. a) Use similar triangles to find the coordinates of the point midway between the points \((x_1, y_1)\) and \((x_2, y_2)\)

b) Use the formula from a) to find the point midway between \((-5,-1)\) and \((9,-3)\).

answers  

a) \(\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)\)  
b) \((2,-2)\)

5. The cost for a new recreational area is estimated to be $7000.00 a square unit. If the area is to be triangular with vertices at \((3,-2)\), \((3,-6)\) and \((7,-1)\), then the estimated cost is:

1) $147,000  
2) $56,000  
3) $49,000  
4) $112,000  
5) NOT

answer  2

6. The point \((x,-1)\) is 13 units from \((3,4)\). Find the sum of all possible values of \(x\).

7. True or False: The following sets of points are collinear. (Use the distance formula)

a) \((5,-6)\) \((-7,9)\) \((0,0)\)  
b) \((0,-3)\) \((3,-1)\) \((-3,-5)\)

answers  

a) False  
b) True

8. Match the correct shaded region with the following sets of numbers.

___a) \(((x,y)/ x<0 \text{ and } y>0)\)  
___b) \(((x,y)/ x>0 \text{ or } y<0)\)  
___c) \(((x,y)/ 0<x<1 \text{ and } 1<y<3)\)  

2)  
3)  
4)  
5) NOT
Assignment 14  Graphs of Functions

1. Let $D_f = \{1, 2, 3, 4, 5\}$. Plot the graphs of the following functions, $f(x) =$
   
   a) $\frac{1}{3x + 2}$  
   b) $\sqrt{1/(2x-1)}$  
   c) $\frac{1}{x}$  
   
   d) $\sqrt{(x-2)^2}$  
   e) $\frac{x}{|x|}$  
   f) $\sqrt{x/(x+3)}$

2. Choose the graph that best represents the following function and label the five points of the graph which are indicated. Label means to give the coordinates.
   
   a) $f(x) = x + 2$  
   b) $g(x) = -2$  
   c) $h(x) = 1 - x^2$
Assignment 14 page 2

3. Let \( f(x) = x - 1 \) and \( g(x) = -\frac{1}{2}x + 2 \). Sketch the graph of both \( f \) and \( g \) on the coordinate system below to determine graphically their point of intersection. Check your result algebraically.

answer \((2,1)\)

4. Which of the following points belong to the graph of the equation \( y = x^{2/3} - x \)?

a) \((9,-3)\)  b) \((8,-4)\)  c) \((-1,0)\)

d) \((27,-18)\)  e) \((\frac{1}{8}, \frac{-1}{8})\)

answers b) , d) and e)

5. Sketch the graphs of the following equations.

a) \( 2|x| + |y| = 0 \)  b) \( |y| = [-x| \)

c) \( \frac{1}{2} y = |x| - x \)  d) \( y = x^2|x| \)

6. Sketch the graphs of the following relations.

a) \( y > |x| \)  b) \((|x| - x)y = 0 \)  c) \([x] = [y] \)
Assignment 15  Direct Variation

1. If (3/4) belongs to the graph of $y = f(x)$ and $y$ is directly proportional to $x$, then the constant of proportionality $m =$

1) 3/4  2) 4/3  3) 12  4) -1  5) NOT
answer  2)

2. Let $y = f(x)$ and $y$ varies directly as $x$. Find the constant $k$ that makes the following equations true.

a) $f(x_1) \cdot f(x_2) = kf(x_1 \cdot x_2)$

b) $1/f(a) = kf(1/a)$

c) $(f(x))^2 = kf(x^2)$

3. If $y$ varies directly as $x^2$ and $y = f(x)$, find the relationship between $f(a/b)$ and $a^2 f(1/b)$.

answer They are equal

4. The cost of carpeting is directly proportional to the number of square yards purchased. What does the constant of proportionality represent in this case? If you could buy 20 sq. yds. for $95.00, how much carpet could you buy for $170? 

answers The cost of one sq. yd.  36 sq. yds.

5. $y$ is directly proportional to $x$. Find $y = f(x)$ such that:

a) $y$ does not increase when $x$ increases

b) $y$ varies directly as $3x$

6. Kepler's third law states that the time it takes a planet to revolve about the sun varies directly as the $3/2$ power of the maximum radius of its orbit. Using 93 million miles as the maximum radius of the Earth's orbit and 142 million miles as the maximum radius of Mars' orbit, how many days does it take Mars to make one revolution about the sun?

answer $365(\frac{142}{93})^{3/2}$ days
Assignment 16  Linear Functions

1. Let \( f(x) \) and \( g(x) \) both be linear functions.
   a) If \( f(x) \) contains \((1,1)\) and \((2,4)\), then \( f(x) = \)
      1) \( 3x-4 \)  2) \( \frac{1}{3}x-4 \)  3) \( 3x-2 \)  4) \( x+2 \)  5) NOT
   b) If \( g(x) \) is parallel to \( f(x) \) in a), and \( g(2) = 5 \), then \( g(x) = \)
      1) \( 3x-1 \)  2) \( 3x-11 \)  3) \( \frac{1}{2}x+4\frac{1}{2} \)  4) \( x+3 \)  5) NOT
   c) If \( g(x) \) contains \((0,3)\) and \((\pi,-1)\), \( f(x) \) is parallel to \( g(x) \) and \( f(\pi/2) = 3 \), then \( g(x) - f(x) = \)
      1) \( 3 \)  2) \( -2 \)  3) \( \pi+4 \)  4) \( -\frac{4}{\pi}(x-\frac{\pi}{2})+3 \)  5) NOT
   answers  a) 3  b) 1  c) 2

2. Sketch the graphs of the following linear functions.
   Find the slope, \( y \)-intercept, and zero for each function.
   a) \( f(x) = -3x + 2 \)  b) \( f(x) = 3 - 4x \)  c) \( f(x) = 2(x-2)+3 \)

3. What can you say about the formula for \( f(x) \) if \( f \) is linear and:
   a) \( f(x+2) = f(x) + 2 \) for every \( x \)
   b) \( |f(x)| = f(|x|) \) for every \( x \)
   c) \( f(2) = -3 \) and \( f(-3) = 2 \)
   d) \( kf(x) = f(kx) \) for every \( x \) and any constant \( k \)
   answers  b) \( f(x) = mx \), \( m \geq 0 \) or \( f(x) = b \), \( b \geq 0 \)
            c) \( f(x) = -x-1 \)  d) \( f(x) = mx \)  \( (b=0) \)
Assignment 16  

4. A projectile fired straight up attains a velocity of \( v \) feet per second after \( t \) seconds of flight, and the relation between the numbers \( v \) and \( t \) is a linear one. If the projectile is fired at a velocity of 160 feet per second and reaches a velocity of 64 feet per second after 3 seconds of flight, find the formula for \( v \) in terms of \( t \). At what time does the projectile reach its highest point?

answers \( v = -32t + 160 \) when \( v = 0, t = 5 \)

5. If the temperature \( h \) feet above Lima is \( T^\circ \), then for practical purposes the associated function can be assumed to be linear. Suppose the temperature in Lima is 50\(^\circ\) and the temperature at 2000 feet is 42\(^\circ\). What is the temperature at 5000 feet?

6. The total accumulation (principal + interest) of an investment \( P \) at \( r\% \) at the end of \( t \) years is \( A \) dollars and the associated function is linear. Find a formula for \( A \) in terms of \( t \) (treat \( P \) and \( r \) as constants). If you invested $100 at 6\% in one of the Lima area banks, how long would it take to double your money. Explain why it would take twice as long to triple your investment as it would to double it.

answers \( A = P + Prt \) You would have $200 at the end of \( 16 \frac{2}{3} \) years. Since the only interest you receive is on the initial investment, it take you as long to accumulate the second $100 as it did to accumulate the first $100.
Assignment 17  Inverse Variation

1. Given that \( y \) is inversely proportional to \( x \) and \((2,8)\) belongs to the function defined by \( y = f(x) \), then \( f(x) = \)

1) \( 4x \)  2) \( \frac{1}{x^4} \)  3) \( \frac{16}{x} \)  4) \( \frac{4}{x} + 6 \)  5) NOT

answer \( \frac{1}{x^4} \)

2. If \((\frac{2}{5},5)\) \((x,y)/ y = f(x) \) and \( y \) is inversely proportional to \( x \), then \( f(x) = \)

1) \( \frac{2}{x^2} \)  2) \( \frac{2}{3x} \)  3) \( \frac{5}{2x} \)  4) \( \frac{5}{x} \)  5) NOT

3. If \( u = f(x) \) and \( v = g(x) \) are both inversely proportional to \( x \) and \( f(2) \geq g(2) \), choose the symbol that makes the following statements true.

a) \( f(-2) \) \( > = < \) \( g(-2) \)

b) \( f(2/3) \) \( > = < \) \( g(2/3) \)

answers a) \<

4. The amount of illumination, measured in lumens, of a light source is inversely proportional to the square of the distance from the source. If the light by the crosswalk in front of Galvin Hall gives off 1200 lumens 3 feet away, how many lumens will it give off at a distance 12 feet away?

answer \( 75 \) lumens

5. A light on a lamp post \( h \) feet high is mounted on top of a wall 6 feet high. A man 6 feet tall stands 5 feet from the base of the wall. Show that the length of his shadow is inversely proportional to \( h \), and calculate \( h \) if his shadow is 4 feet long.

answer \( h = 7 \frac{1}{2} \) feet.
Assignment 18  Exponential Functions  
And Their Graphs

1. Which of the following best represents the graph of the exponential function with base 1?

1)  
2)  
3)  
4)  
5)  

2. Let \( f(x) = b^x \)
   a) If \((1, n) \in f\), then \( f(n) = \)
      1) \( n \)  2) 1  3) \( n^2 \)  4) \( b^{n+1} \)  5) NOT
   b) If \((2, \frac{1}{2}) \in f\), then \( f(\frac{1}{2}) = \)
      1) \( 5^{-1/4} \)  2) \( \sqrt{2} \)  3) \( 4\sqrt{2} \)  4) \( (\frac{1}{2})^{2/5} \)  5) NOT
   c) If \((0, 1) \in f\), then \( b = \)
      answers  a) 3  b) 1

3. Given that \( f(x) \) is an exponential function, answer the following true or false.
   a) \( f(px) = (f(x))^p \)  b) \( f(x+y) = f(x)f(y) \)
      answers  a) true  b) true

4. How many real solutions do each of the following equations have?
   a) \( 4^x = -3 \)  b) \( 3^x = 2 \)  c) \( 3^x = 2 \)
   d) \( 4^{-x} = -3 \)  e) \( 4^{-x} = 3 \)  f) \( x^2 = 5 \)
5. Which of the following define exponential functions?
   a) \( f(x) = 2^{3x} \)  
   b) \( f(x) = 3 \cdot 2^x \)  
   c) \( f(x) = 3^{2x+1} \)

   **answer**  a

6. Suppose that the County Engineer reported a fissure in Ferguson Lake Reservoir was allowing water to leak out at such a rate that at the end of any hour the amount of water in the Reservoir is 0.9 of what it was at the beginning of the hour.
   a) If the Reservoir contained 40,000,000,000 gallons of water at noon, find a formula for the amount of water in the Reservoir \( t \) hours after noon.
   b) How much water will be in the Reservoir at 4 p.m.?

   **answers**  a) \( A = 4 \cdot 10^{10} \cdot (0.9)^t \)  
                b) 2.6244 \( \times 10^{10} \)

7. Sketch the graph of
   \( \{(x,y)/ 0 < x < 1 \text{ or } 1 < y \leq 3\} \)

8. Sketch the graph of
   \( y = \lfloor x + \lfloor x \rfloor \rfloor \text{ for } x \in (-2,3] \)

9. \( y = f(x) \) and \( y \) varies directly as \( x \). Find \( k \) such that
   \[
   \frac{f(x_1)}{f(x_2)} = k \frac{x_1}{x_2}
   \]

10. Show that if \( y \) varies directly as \( x \), then \( x \) must vary directly as \( y \). Replace the word directly with indirectly in the preceding statement.
11. If $z$ is inversely proportional to $t^3$, $z = g(t)$ and both $(2,5)$ and $(4,b)$ are on the graph of $z = g(t)$, then $b = \phantom{1}$

1) 25  2) 10  3) $4/5$  4) $5/8$  5) NOT

answer  4

12. If $f(x)$ is an exponential function and $(4,16) \in f$, then $f(3) = \phantom{1}$

1) 8  2) 9  3) 12  4) 13  5) NOT

answer  1
Assignment 19  Definition Of The Logarithm

1. Matching

\[ A^B = 7 \]  a) \( \log_B A = 7 \)
\[ A^7 = B \]  b) \( \log_A B = 7 \)
\[ B^A = 7 \]  c) \( \log_A B = 7 \)
\[ B^7 = A \]  d) \( \log_B A = 7 \)
\[ 7^A = B \]  e) \( \log_{A} 7 = B \)

answers f, c, d, a, e

2. Solve each of the following for \( x \)

a) \( \log_5 x = 2 \); \( x = \)
   1) \( \frac{1}{5} \)  2) 64  3) 3  4) 36  5) NOT

b) \( \log_3 27 = x \); \( x = \)
   1) 9  2) 27  3) 3  4) \( \frac{1}{9} \)  5) NOT

c) \( \log_4 2 = x \); \( x = \)
   1) 16  2) 2  3) 8  4) 4  5) NOT

d) \( \log_x 81 = 4 \); \( x = \)
   1) \( x^4 \)  2) 20 \( \frac{1}{4} \)  3) 3  4) 324  5) NOT

e) \( \log_{10} 10 = 4 \); \( x = \)
   1) 10^4  2) 4^{-10}  3) \( \sqrt[5]{5} \)  4) \( \sqrt{10} \)

answers  a) 4  b) 3  d) 3

3. Solve each of the following for \( x \).

a) \( \log_x 1 = 0 \)

b) \( \log_7 x = 0 \)

c) \( x^{\log_x 7} = 7 \)

d) \( x^{\log_x x} = 7 \)

answers  a) \( x > 0 \)  c) \( x > 0 \); \( x \neq 1 \)
4. The number 1 is not a suitable number for a logarithmic base because
   a) 1 is not a prime number
   b) any number raised to the first power is equal to that number
   c) exponents of 1 are not written
   d) 1 raised to any number is 1
   e) none of these explain why 1 is not suitable as a logarithmic base

5. If \( \log_b x = 5 \), then \( \log_{1/b} x = \)
   1) 5  2) -5  3) 1/5  4) \( \log_{1/b}(1/x) \)  5) NOT

6. Solve for \( x \).
   a) \( 2^{\log_2 7} = x \); \( x = \)
      1) 2  2) 4  3) 7  4) 49  5) NOT
   b) \( x^{\log_6 9} = 9 \); \( x = \)
      1) 6  2) 2/3  3) 3/2  4) 9  5) NOT
   c) \( 6^{\log_6 7} = 7 \); \( x = \)
      1) 6  2) 7  3) 6/7  4) 7/6  5) NOT
   d) \( 3^{\log_3 7} = 7 \); \( x = \)
      1) 9  2) 7^3  3) 3  4) 7  5) NOT
   e) \( \log_6 6^x = 3 \); \( x = \)
      1) 6^6  2) 6^3  3) 3  4) 3^6  5) NOT

answers  a) 3  c) 1
Assignment 20  
Fundamental Properties
Of Logarithms

1. Given that \( \log_b 2 = a, \log_b 3 = c, \log_b 5 = d, \) and
\( \log_b 7 = e, \) then

a) \( \log_b 4 = \)
1) \( a^2 \)  
2) \( 2a \)  
3) \( e - c \)  
4) \( 2^a \)  
5) NOT

b) \( (\log_b 2)^2 = \)
1) \( a^2 \)  
2) \( 2a \)  
3) \( (e - c)^2 \)  
4) \( 2^{\log_b a} \)  
5) NOT

c) \( \log_b 5 \div \log_b 7 = \)
1) \( \frac{d}{e} \)  
2) \( d - e \)  
3) \( \log_b \frac{5}{7} \)  
4) \( \log_b (5/7) \)  
5) NOT

d) \( \log_b 3^2 = \)
1) \( 9 \)  
2) \( c^2 \)  
3) \( 2c \)  
4) \( a + e \)  
5) NOT

e) \( \log_b (.6) = \)
1) \( c - d \)  
2) \( 10\log_b 6 \)  
3) \( c/d \)  
4) \( \frac{ad}{c+e} \)  
5) NOT

f) \( \log_b 10 = \)
1) \( a + d \)  
2) \( ad \)  
3) \( c + e \)  
4) \( d(c - 1) \)  
5) NOT

answers  
c) 1  
d) 3  
e) 1

2. Simplify the following expressions

a) \( \log_b x - .75 \log_b x + \log_b x^2 = \)
1) \( \log_b x^2 + .25 \log_b x \)  
2) \( 2(\log_b x) + \log_b \sqrt{x} \)  
3) \( \frac{9}{4} \log_b x \)  
4) \( \log_b (x^2 + .25x) \)  
5) NOT
2b) \( \log_b \left| y^3 + z^3 \right| - \log_b \left| y+z \right| = \)
1) \( \log_b \left| y^2 + z^2 \right| \)  
2) \( \log_b \left| y^4 + z^4 \right| \)  
3) \( \log_b \left( y^4 + y^3 z + yz^3 + z^4 \right) \)
4) \( \log_b (x^2 - xy + y^2) \)  
5) NOT

answers  
a) 3  
b) 5

3. If \( \log_b 2 = .69 \) and \( \log_b x = 1.22 \), then
a) \( \log_2 x = \)
1) .5656  
2) .53  
3) -.53  
4) 1.7681  
5) NOT

b) \( \log_2 b = \)
1) .5656  
2) 1.4493  
3) .8197  
4) 1.7681  
5) NOT

answer  
b) 2

4. Solve the following equations for \( x \)

a) \( \left| \log_4 x \right| = 2 ; \ x \in \)

b) \( \log_e (3/5) + \log_e (12/7) - \log_e (36/35) = \log_e x ; \ x = \)

c) \( \log_b x^2 = 6 - 2a + 2\log_b \left( \frac{a^3 b^a}{b^2} \right) ; \ x = \)

answers  
a) \{16,1/16\}  
b) 1  
c) \( a^3 \)
Assignment 21  Logarithmic Functions  
And Their Graphs

1. Graph $y = b^x$ and $y = \log_b x$, for $b$ equal to any integer greater than 1, on the same coordinate system. The equation of their line of symmetry (the line on which the paper could be folded so the two graphs coincide) is:

1) $y = x$  
2) $y = -x$  
3) $y = bx$  
4) $y = -bx$  
5) NOT

2. If $f$ is the logarithmic function with base $8$, find
   a) $f(32)$  
   b) $f(16)$  
   c) $f(1/8)$  
   d) $f(\sqrt[3]{4})$  
   e) $-\frac{1}{2}f(\frac{1}{2})$  
   f) $[f(1/18)]$  
   g) $[f(1776)]$

   answers  
   a) $5/3$  
   c) $-1$  
   f) $-2$

3. The base of the logarithmic function containing $(3, 125)$ is:

1) $41\frac{2}{3}$  
2) $375$  
3) $3$  
4) $5$  
5) NOT

4. The base of the logarithmic function whose graph contains the point $(5, 1)$ is:

1) $5$  
2) $1$  
3) $1/5$  
4) $25$  
5) NOT

answer  
1)
Assignment 22   Logarithms To The Base 10

1. Use the tables in the book(pp. 430-1) to solve for x.

a) $10^x = 7.63$

b) $10^x = .0297$

c) $\log x = 3.5502$

d) $\log x = .9474$

e) $\log x = .6395 - 4$

f) $\log x = -2.2096$

answers  a) .8825   c) 3550   d) 8.86
           e) .000436  f) .00621
Assignment 23  

Interpolation

1. Find x to 4 significant digits.
   a) log x = .4353 ;  x =
      1) 2.725  2) 2.726  3) 2.724  4) 4.353  5) NOT
   b) log x = 2/3 ;  x =
      1) .6667  2) 4.642  3) 4.648  4) .4640  5) NOT
   answers a) 3  b) 2

2. Find the number x.
   a) 10^x = .5973  
   b) 10^x = 19.46
   answers  a) -.2238  b) 1.2891

3. Express as a decimal.
   a) 10^{-2.734}  
   b) \frac{3}{\sqrt{255}}  
   c) \frac{5}{\sqrt{10}}
   answers  a) 1.877  c) 1.585

4. Using \sqrt{9} = 3 and \sqrt{16} = 4 and linear interpolation,  
   find \sqrt{14} . Discuss the accuracy of your result.
   answer  26/7

5. Use linear interpolation to find f(3.6) if f(2) = .765  
   and f(4) = 3.615 .
Assignment 24  Computations With Logarithms

1. Use logarithms to find N.

a) \( N = \frac{253 \times 2.46}{3892 \times .0068} \)

b) \( 10^N = \frac{411}{643} \)

answers  a) 23.52  b) -.1944

2. Solve or simplify each of the following:

a) \( \log_{16} x = \frac{3}{4} \);  \( x = \)

1) 12  2) 8  3) 21\(\frac{1}{2} \)  4) 6  5) NOT

b) \( \log_66^3 = x \);  \( x = \)

1) 6  2) 3  3) 3  4) 6  5) NOT

c) \( \log_bx^4 - \log_b\sqrt{x} = \)

1) \( \log_b(x^4 - \sqrt{x}) \)  2) 4 \( \log_b\sqrt{x} \)  3) \( \frac{7}{2} \log_bx \)

4) \( \frac{3}{2} \log_bx \)  5) NOT

d) If \( f \) is the logarithmic function with base 8 and \( f(\frac{1}{2}) = x \), then \( x = \)

1) 1/2  2) 2\(\sqrt{2} \)  3) -1/3  4) 1/16  5) NOT

answers  a) 2  b) 3  c) 3  d) 5

3. Solve for \( x \).

a) \( x = 10^{1.574} \)

b) \( \log x = 3.9329 - 4 \)

answers  a) 37.5  b) .8568
1. Solve and/or evaluate \( x \)
   
   a) \( 2^x = 3 \); \( x = \)
   
   1) \( \log_2 3 \)  
   2) \( \sqrt[3]{2} \)  
   3) \( \log_2 3 \)  
   4) \( \sqrt[3]{2} \)  
   5) NOT

   b) \( 7^x = 7/4 \); \( x = \)
   
   1) \( .3476 \)  
   2) \( .3500 \)  
   3) \( .2340 \)  
   4) \( .3524 \)  
   5) NOT

   c) \( (.001)^x = 3 \); \( x = \)
   
   1) \( -2.003 \)  
   2) \( -1 \)  
   3) \( -4476 \)  
   4) \( -1590 \)  
   5) NOT

   d) \( 5^{-x} = 6 \); \( x = \)
   
   1) \( -1.1133 \)  
   2) \( -0.792 \)  
   3) \( -3333 \)  
   4) \( -1.2 \)  
   5) NOT

   e) \( 4^{2-x} = 3 \); \( x = \)
   
   1) \( 2.1250 \)  
   2) \( 2.7924 \)  
   3) \( 1.2076 \)  
   4) \( 1.1250 \)  
   5) NOT

   f) \( 6^{x-2} = 4^{x+1} \); \( x = \)
   
   1) \( 7 \)  
   2) \( 12.2572 \)  
   3) \( 15.6763 \)  
   4) \( 1.5638 \)  
   5) NOT

   g) \( 10^{x^2} = 6 \); \( x = \)
   
   1) \( \pm 2.4495 \)  
   2) \( \pm 7.246 \)  
   3) \( \pm 8.456 \)  
   4) \( \pm 8.82 \)  
   5) NOT

   h) \( (10^x)^2 = 6 \); \( x = \)
   
   1) \( \pm 0.7782 \)  
   2) \( \pm 3.991 \)  
   3) \( \pm 8.816 \)  
   4) \( \pm 1.8456 \)  
   5) NOT

   answers  a) 3  d) 1  e) 3  g) 4

2. Solve the following equations for \( x \)
   
   a) \( \log (x^2 + 3x + 2) - \log (x + 2) = 2 \)

   b) \( \log (x + 2) - \log (x + 1) = 1/2 \)
2c) \( 3^{\log x} = 6x \)

d) \( \log |x-2| + \log |x+2| = -2 \)

answers b) \(-0.5375\)  c) \(0.03249\)  d) \(\pm 2.0025, \pm 1.9975\)

3. If the graph of the function \( (x, n \cdot 10^{kx}) \) contains the points \((0,9)\) and \((1,18)\), then \(nk = \)

1) \(10^x\)  2) \(4.2939\)  3) \(2.7090\)  4) \(1.9709\)  5) NOT

4. A certain downtown Lima Bank guarantees that your savings, if left for 12 years, will double. If the bank compounds the interest annually, what interest rate are they offering?

answer 5.9%
Assignment 26   The Trigonometric Point

1. Locate the following trigonometric points on a unit circle and determine the coordinates of each:
   (3 points to a circle)

Example: \( P(\pi) \)

a) \( P(-2\pi) \)

b) \( P\left(\frac{11}{2}\pi\right) \)

c) \( P\left(-\frac{7}{4}\pi\right) \)

d) \( P\left(\frac{5}{3}\pi\right) \)

e) \( P\left(-\frac{4}{3}\pi\right) \)

f) \( P\left(-\frac{5}{6}\pi\right) \)

answers  a) (1,0)  b) (0,-1)  c) \( (\sqrt{2}/2,\sqrt{2}/2) \)

d) \( (-1/2,\sqrt{3}/2) \)  e) \( (-1/2,\sqrt{3}/2) \)  f) \( (-\sqrt{3}/2,-1/2) \)

2. Locate the following points on a unit circle and state the quadrant in which each lies:

Example: \( P(\pi) \)

\( P(3\pi/2) \)

a) \( P(3\pi/2) \)  b) \( P(2) \)  c) \( P(4) \)  d) \( P(7.75) \)

answers  b) II  d) I

3. Let \( P(t) = (x,y) \). Convince yourself by drawings that the following are true.

a) \( P(\pi-t) = (-x,y) \)  b) \( P(-t) = (x,-y) \)

4. If \( P(t) = P(2) \), then \( t \in \) (let \( k \) be a constant)
   \[ \{2-\frac{kn\pi}{2}\} \quad \{2+\frac{kn\pi}{2}\} \quad \{2+2k\pi\} \quad \{2+k\pi\} \quad \text{NOT} \]

answer  3
Assignment 27 The Trigonometric Functions

1. Choose the letter on the number line that best corresponds to the following values:
   a) \( \cos(1.5) \) ______
   b) \( \tan(3) \) ______
   c) \( \sin(2) \) ______

   answers a) w c) x

2. Show that \( \tan^2 t = \sec^2 t - 1 \) for any number \( t \) in the domain of the tangent function. (Hint: \( \sin^2 t + \cos^2 t = 1 \))

3. Show that each of the following expressions has the value 1 for each number \( t \) for which the expression is defined.
   a) \( \frac{\tan t + \cot t}{\sec t \cdot \csc t} \)
   b) \( \frac{1}{2}(\cot t \cdot \sin t \cdot \sec t + \sin^2 t + \frac{\cos t}{\sec t}) \)
   c) \( \frac{\sin t + \cos^2 t \cdot \csc t}{\csc t} \)

4. Graph the following with their coordinates labeled.
   a) \( P\left(\frac{\pi}{2}\right) \)
   b) \( P\left(\frac{5\pi}{4}\right) \)
   c) \( P\left(\frac{7\pi}{6}\right) \)

   answers a) \((0,1)\) b) \((-\sqrt{2}/2, -\sqrt{2}/2)\) c) \((-\sqrt{3}/2, -1/2)\)
5. Complete the following table.

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<th>t</th>
<th>P(t)</th>
<th>sin t</th>
<th>cos t</th>
<th>tan t</th>
<th>cot t</th>
<th>sec t</th>
<th>csc t</th>
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<td>...</td>
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<td>$\sqrt{3}$</td>
<td>$-2\sqrt{3}/3$</td>
<td>-2</td>
<td></td>
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<tr>
<td>5π/4</td>
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<tr>
<td>4π/3</td>
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<tr>
<td>3π/2</td>
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<tr>
<td>5π/3</td>
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<tr>
<td>7π/4</td>
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<tr>
<td>11π/6</td>
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<tr>
<td>2π</td>
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</tbody>
</table>
Assignment 28 Trigonometric Tables

Use the tables on pages 432-5 and interpolate if necessary.

1. Find a member of the solution set for the following equation
   \[ \sin t = \frac{3}{4} \]

   Answer: 0.848

2. Find a value for \( t \) such that
   \[ \cos t = \frac{3}{5} \]

3. If \( \csc t = 1 \), then \( t \) could be equal to
   a) 1  b) \( \pi \)  c) \( \pi/2 \)  d) 0  e) NOT

4. Dr. Lee said that for small values of \( x \), \( \sin x \) is (approximately) equal to \( x \). Using the tables and rounding values to hundredths, what is the greatest value of \( x \) for which Dr. Lee's statement is true?
Assignment 29 Functional Values At Any Number t

1. Locate the domain element of each of the following on the unit circle provided; graph the reference number $t_1$ with its coordinate and use Table II in the text to evaluate the following. (Use $\pi = 3.142$ and $2\pi = 6.283$)

   a) $\sin \frac{\pi}{3}$
   b) $\cos \frac{\pi}{6}$
   c) $\cot(-\frac{\pi}{4})$

2. Find a number $t$ falling in the 3rd quadrant and belonging to the solution set of

   a) $\cos t = -\frac{1}{2}$
      1) $-\sqrt{3}/2$  2) $-\frac{5\pi}{6}$  3) $\frac{10\pi}{3}$  4) $\frac{5\pi}{3}$  5) NOT
   b) $\sin t = -\sqrt{3}/2$
      1) $-\pi/2$  2) $\frac{7\pi}{6}$  3) $\frac{4\pi}{3}$  4) $\frac{11\pi}{6}$  5) NOT

   answers  a) 3  b) 3
Assignment 30  
Graphs Of The Trigonometric Functions

1. Which of the following graphs best represents the equation \( y = 2 \cos x \) on \((0, \pi)\), the interval \(\{0 < x < \pi\}\) ?

1) \[\text{Graph 1}\]  
2) \[\text{Graph 2}\]  
3) \[\text{Graph 3}\]  
4) \[\text{Graph 4}\]  
5) NOT

2. Sketch the graph of \( y = \sin 2x \) on \((0, \pi)\).

\[\text{Graph of } y = \sin 2x \text{ on } (0, \pi)\]

3. Which of the following graphs best represents the equation \( y = |\sin x| \) ?

1) \[\text{Graph 1}\]  
2) \[\text{Graph 2}\]  
3) \[\text{Graph 3}\]  
4) \[\text{Graph 4}\]  
5) NOT

4. Sketch the graph of \( y = \sin |x| \)

\[\text{Graph of } y = \sin |x|\]

answer graph is represented by 3) in problem 3
1. Using the equation \( \frac{5\pi}{12} = \frac{\pi}{4} + \frac{\pi}{6} \), find \( \cos\left(\frac{5\pi}{12}\right) \).

2. Show that \( \cos\left(v + \frac{\pi}{2}\right) = -\sin v \) for any number \( v \). What does this identity tell you about how the sine and cosine graphs are related?

3. Find a member of the solution set of \( -\sin \frac{\pi}{3} = \cos x \)

   answer Using problem 2 \( x = \frac{\pi}{3} + \frac{\pi}{2} = \frac{5\pi}{6} \).

4. If \( f(-x) = f(x) \) for every number \( x \) in the domain of \( f \), then \( f \) is called an even function. If \( f(-x) = -f(x) \) for every number \( x \) in the domain of \( f \), then \( f \) is called an odd function. For example, the cosine function is an even function and the sine function is an odd function. Determine if the following equations are even, odd, or neither.

   a) \( f(x) = x^2 + 1 \)
   b) \( f(x) = x^3 + 1 \)
   c) \( f(x) = x\cos(-x) \)
Assignment 32   Addition Formulas For The Trigonometric Functions

1. \( \frac{5\pi}{12} = \frac{3\pi + 2\pi}{12} = \frac{3\pi}{12} + \frac{2\pi}{12} = \frac{\pi}{4} + \frac{\pi}{6} \) or
\[ \frac{5\pi}{12} = \frac{8\pi - 3\pi}{12} = \frac{8\pi}{12} - \frac{3\pi}{12} = \frac{2\pi}{3} - \frac{\pi}{4} \]

Express the following as sums or differences of fractions with denominator 2, 3, 4, or 6. Explain why we are interested in these denominators.

a) \( \frac{\pi}{12} \)

b) \( \frac{7\pi}{12} \)

c) \( \frac{11\pi}{12} \)

2. Evaluate the following:

a) \( \cos(\frac{7\pi}{12}) \)

b) \( \sin(\frac{\pi}{12}) \)

c) \( \tan(\frac{11\pi}{12}) \)
Assignment 33 Values Of The Trigonometric Functions At Multiples Of \( t \)

1. Complete and simplify

\[
\tan 2t = \tan(t + t) = \frac{2\tan t}{1 - \tan^2 t}
\]

**answer** \( \frac{2\tan t}{1 - \tan^2 t} \)

2. \( \sin \frac{\pi}{6} = \)

1) \( \frac{1}{2}\sqrt{2 + \sqrt{2}} \)  
2) \( \frac{1}{2}\sqrt{2 - \sqrt{2}} \)  
3) \( \frac{\sqrt{2}}{4} \)  
4) \( \frac{1}{2}(2 - \sqrt{2}) \)  
5) NOT

**answer** 2

3. \( \tan \frac{\pi}{6} = \)

1) \( 2\sqrt{2} - 4 \)  
2) \( \frac{\sqrt{2}}{2} - 1 \)  
3) \( \sqrt{2} - 2 \)  
4) \( \sqrt{2} - 1 \)  
5) NOT

**answer** 4

4. Simplify the following expressions

a) \( (\sin x - \cos x)^2 + \sin 2x + 1 = \)

**b) \( \frac{1 + \cos 2t}{1 - \cos 2t} = \)**

**answer** a) 2
Assignment 34  Summary Of Trigonometric Identities

1. Simplify the following expressions

   a) \((\frac{\sec t}{\cos^2 t} - \tan t \cdot \sin t \cdot \sec^2 t)^2 - 1\)

   b) \(\cot x \cdot \cos x + \sin x\)

   answer  a) \(\tan^2 t\)

2. Find a solution to the following equation

   \(\tan^2 x + \sec^2 x = 7\)

   (HINT: subt 1 - both sides of the equation)

   answers  \(\frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3},\) etc.
Assignment 35 The Equation $y = A \sin(ax + b)$

1. The graph of $y = \cos(x + \frac{3\pi}{2})$ is best represented by

1) \hspace{2cm} 2)

3) \hspace{2cm} 4)

5) NOT

2. Sketch the graph of $y = \tan(x - \frac{\pi}{2})$

3. The graph of $y = \sin(2\pi x + \pi)$ is best represented by

1) \hspace{2cm} 2)

3) \hspace{2cm} 4)

5) NOT

answer 3
4. The sum of the frequency and the phase shift of 
\[ y = \sin(2\pi x + \pi) \] 
is
1) 3π  2) 3/2  3) \( \frac{1}{2\pi} - \pi \)  4) 1/2  5) NOT
answer  4

5. Write the following in the form \( A\sin(ax+b) \) where a and A are both positive:
\[-3\sin(4\pi x + 2)\]

HINT: sketch the graph

6. Sketch the graph of 
\[ y = \left\lfloor \cos \pi x \right\rfloor \text{ on } \{0 \leq x \leq 6\} \]

\[ \begin{array}{ccccccc}
0 & 1 & 2 & 3 & 4 & 5 & 6 \\
\end{array} \]

7. Locate \( t \) and \( t_\perp \) on the unit circle for \( \tan \frac{14}{1} \) and then use the tables to evaluate it.

8. Give an example of an even function; an odd function.

9. Find \( \sin(13\pi/12) \)

10. Simplify the expression
\[ \cos 2t + \sin 2t + (\sin t - \cos t)^2 \]
Assignment 37  Some Facts About Circles

1. One of the wheels in the air conditioning machinery in Galvin Hall is 36 inches in diameter and rotates at the rate of 70 revolutions per minute. Find the velocity in feet per second of a rivet head in the rim of the wheel.

answer  \( \frac{7\pi}{2} \) feet per second

2. Using \( \pi = 3.14 \) and the latitude of Lima to be 42° north and assuming the earth is a sphere with radius 3960 miles, find to the nearest mile how far Santa Claus has to travel to come to Lima, if he starts from his toy shop at the North Pole.

answer  3316 miles

3. The radii of the wheels of Mr. Parete's bicycle are 13 inches, the radius of the front sprocket is 5 inches, and the radius of the back sprocket is 3 inches. The arms fastening the pedals to the front sprocket are 9 inches in length. How far do the pedals travel when the back wheel makes one revolution?

answer  \( \frac{54\pi}{5} \) inches

4. The hour hand on the clock on the second floor of Galvin Hall is 4 inches long. What is the area of the region that it "sweeps out" during the time interval from 12 o'clock till the next time that the minute and hour hands are together?

answer  \( \frac{16\pi}{11} \) square inches
Assignment 36  Angles

1. Complete the following table

<table>
<thead>
<tr>
<th>Width of θ</th>
<th>0°</th>
<th>30°</th>
<th>60°</th>
<th>120°</th>
<th>135°</th>
<th>180°</th>
</tr>
</thead>
<tbody>
<tr>
<td>in radians</td>
<td>0</td>
<td>π/4</td>
<td>π/3</td>
<td>π/2</td>
<td>5π/6</td>
<td>5π/3</td>
</tr>
</tbody>
</table>

2. Degree and radian equivalents

a) 225° =
   1) 585°  2) 3π/2  3) 7π/6  4) 5π/4  5) NOT

b) 320° =
   1) 11π/6  2) 3π/2  3) 2π/3  4) 5π/3  5) NOT

c) -7π/6 =
   1) 5π/6  2) 150°  3) -210°  4) -150°  5) NOT

d) 6 radians =
   1) 344°  2) 1080°  3) 2π  4) π/30  5) NOT

answers a) 4  d) 1
Assignment 38  The Geometric Approach To  
The Trigonometric Functions

1. Using the unit circle and coordinate system given,  
locate the following points and find the width in  
degrees of the smallest positive angle in standard  
position whose terminal side contains the point.  

a) $(4,3)$  
b) $(2,2\sqrt{3})$  

answer  
a) $37^\circ$  

2. A spider has spun a web consisting of concentric  
circles and lines through the center of the circles.  
The web has a coordinate system with origin at the  
center of the circles and one line passing through  
the point $(4,3)$. The spider starts at the point  
$(4,3)$ and proceeds to the unit circle and then on  
the unit circle to the point $(1,0)$ where a fly is  
cought. How far did the spider travel for his  
lunch? (Use 1a)

3. Find the width in degrees of the angle of inclination  
of the following lines.  

a) $y + 1 = -3(4-x)$  
b) $(0,1)$
1. Complete the following table without reference to the text.

<table>
<thead>
<tr>
<th>°</th>
<th>0°</th>
<th>30°</th>
<th>45°</th>
<th>60°</th>
<th>90°</th>
<th>120°</th>
<th>135°</th>
<th>150°</th>
<th>180°</th>
<th>210°</th>
<th>225°</th>
</tr>
</thead>
<tbody>
<tr>
<td>sin θ</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>cos θ</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tan θ</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

2. Fill in the width of the acute angles in degrees in the following right triangles

a)

b)

Answers: a) 37°, 53°

3. Fill in the missing angle in degrees and the lengths of the sides in the following triangle

Answers: 48°, 5.4024, 8.0743

4. Find θ if θ is an acute angle of a right triangle and θ satisfies the following equation

a) \( \cos θ = \sin(θ+20°) \)

b) \( \tan θ = \cot 4θ \)

Answer: a) \( θ = 35° \)
5. Two of our OSU Lima aerospace enthusiasts were on the athletic field behind the Student Activity Building flying model airplanes. They both had the same length guide line attached to the planes. The angle of inclination of one of the planes' guide line was $32^\circ$ and that of the other was $39^\circ$. If the two planes made one complete revolution of the pilots in the same amount of time, find the ratio of the speed of the faster plane to the speed of the slower.

6. The exhaust fans in the Technical Education Laboratory are connected to a motor by an uncrossed belt running around two pulleys whose radii are 4 inches and 8 inches and whose centers are 24 inches apart. (See illustration below) Determine the length of the belt.

b) How long is the belt if it is crossed once?

\begin{align*}
\text{answers} & \quad a) \ 85.4 \text{ inches} \\
& \quad b) \ 89.6 \text{ inches}
\end{align*}
Assignment 40 The Law Of Sines

1. Find the missing parts of the following triangle

![Triangle Diagram]

a) answers $75^\circ, 8, 4.14$

2. Either show that no triangle exists or find the missing parts of the triangles with the following measurements

a) $b = 8, c = 14, \gamma = 69^\circ$

b) $\alpha = 80^\circ, \beta = 53^\circ, a = 10$

answers $\gamma = 47^\circ, b = 8.11, c = 7.43$

3. A weather balloon was sighted at the Lima Mall and on the OSU Lima Campus at the same time. The angle of elevation of the balloon was $27^\circ$ at the Mall and $32^\circ$ on Campus. Assuming the distance between Campus and the Mall is 7 miles, find the altitude of the balloon.

4. A rectangular box with lateral sides two feet high had its top and bottom removed. The box then had to be distorted into a parallelogram shape in order to house a thin steel sheet that was 8 feet long. The sheet of steel made angles of $27^\circ$ and $35^\circ$ with the sides of the box. Find the volume of the original rectangular box.
Assignment 41  The Law Of Cosines

1. Find the remaining parts of the following triangles (round radical approximations to ten-thousandths i.e. $\sqrt{3} = 1.7321, \sqrt{21} = 4.5826, \sqrt{99} = 9.9499$, etc.)

   a) \[
   \begin{tikzpicture}[baseline={([yshift=-.5ex]current bounding box.center)}]
   \draw (0,0) -- (4,0) -- (4,4) -- cycle;
   \node at (2,0) {$4$};
   \node at (4,2) {$5$};
   \node at (2,2) {60\degree};
   \end{tikzpicture}
   \]
   b) \[
   \begin{tikzpicture}[baseline={([yshift=-.5ex]current bounding box.center)}]
   \draw (0,0) -- (9,0) -- (5,8) -- cycle;
   \node at (9,4) {$5$};
   \node at (13,4) {$8$};
   \end{tikzpicture}
   \]
   answers a) $4.5826, 71\degree, 49\degree$ b) $84\degree, 62\degree, 34\degree$

2. A fisherman on the bank of Ferguson Lake Reservoir is due west of the Student - Activities Building and southwest of the Proctor and Gamble Plant. If he hears the four o'clock whistle from the plant at 4 seconds after four and hears the four o'clock bell from campus at 5 seconds after four and if he knows that sound travels at the rate of 1100 feet per second, then he can find the distance from the Student Activities Building to Proctor and Gamble. Show that his calculations of 3923 feet is a good approximation.

3. A rocket is launched from Cape Kennedy but due to a technical error is off course by $10\degree$ for a moon orbit 290000 miles away. If an inflight correction is to be sent to the rocket when it is 100000 miles from the earth, how many degrees should the course be altered to send the rocket to the original point of orbit entry?
4. \( \frac{\pi}{18} \) (radians) = 
   1) \( \frac{37\pi}{18} \)  2) 10°  3) 20°  4) 35°  5) NOT

   answer 2

5. Find the missing parts (measurements) of the following triangles

   a)
   \[ \begin{array}{c}
   20^\circ \\
   4 \\
   \end{array} \]

   b)
   \[ \begin{array}{c}
   73^\circ \\
   40^\circ \\
   12 \\
   \end{array} \]

   c)
   \[ \begin{array}{c}
   6 \\
   50^\circ \\
   2\sqrt{3} \\
   \end{array} \]

   answers c) \( 2\sqrt{3}, 30^\circ, 120^\circ \)
1. Refer to the three "triangular" regions that have been labeled on the map accompanying this exercise. The measurements of parts of the regions are given below. Assuming that each of these regions have sides a, b, and c and angles $\alpha$, $\beta$, $\gamma$, find the area of each region.

Region 1 $b = 7$, $c = 10$, $\alpha = 30°$
Region 3 $c = 4\sqrt{3}$, $\beta = 40°$, $\gamma = 60°$
Region 2 $a = 6$, $b = 6$, $c = 9$

answers 1) 17.50 3) 17.54 2) 17.89

2. Find the radius of the circle inscribed in the triangle that has sides 4, 5, and 7. Try to construct a triangle and inscribed circle with the above measurements (Use any convenient unit of measure).

answer $\frac{1}{2} \sqrt{6}$

3. Show how the area of two similar triangles are related. How are the radii of the inscribed circles related? (The sides of similar triangles are proportional with constant of proportionality k)

4. Find the area of the following figure, a union of two parallelograms.

![Diagram of a union of two parallelograms](https://via.placeholder.com/150)
Assignment 43  The Complex Numbers

1. Match the answers to the right with the problems.

   a) \( (5-2i)+(3+4i) \)  1) 27
   b) \( 2-5i+4+3i-3 \)  2) 8+20i
   c) \( (5-2i)(2-i) \)  3) 3-2i
   d) \( (6-i)(2+3i)-(7-4i) \)  4) 9i+8
   e) \( (i+3)(2i-3)(2+3i) \)  5) -9+5i
   f) \( (2+3i)-(3+(-i-9)) \)  6) -9+25\sqrt{2}i
   g) \( (\sqrt{2}i-3)^3 \)  7) 6
   h) \( 2i(2-i)(2+i) \)  8) 8+2i
   i) \( (\sqrt{2}+5i)(\sqrt{2}-5i) \)  9) 8-9i
   j) \( 6i-i(2i-3(1-2i)) \)  10) 10i
   k) \( i(i(3+2i)-3(1-2i)) \)  11) 36-28i
   l) \( 4(2-3i)(3+i) \)  12) -13-27i

   answers 8, 3, 9, 2, 14, 8, 6, 10, 1, 4, 5, 11

2. Show that \( \{ -2i, 2i \} = \{ x^2 + 4 = 0 \} \) Let \( x = a+bi \)

3. Consider the following functions defined over \( \mathbb{C} \), i.e. \( D_f = \mathbb{C} \). Calculate \( f(2i) \) and \( f(i-1) \) for each.

   a) \( f(z) = (3z-2) \)

   b) \( f(z) = z^2 + 2z - 3i + 1 \)

   answers a) \( 6i - 2 \), \( -3 + i \)
4. If \( f(z) = (iz)^2 \) and \( D_f = \{ C/ \text{the non-real part of } z \text{ is zero} \} \), then \( R_f \), the range of \( f \), is

1) \( \mathbb{R} \)  
2) the non-negative reals  
3) the non-positive reals  
4) the set of imaginary numbers  
5) NOT

5. If \( 3u - 2v = -6 + 8i \) and \( 2u + 4v = 4 + 0i \), then \( u + v = \)

1) \( \frac{1}{2} + i \)  
2) \( \frac{3}{2} - i \)  
3) 2  
4) -1 + 2i  
5) NOT

answer 1
Assignment 44  The Conjugate Of A Complex Number

1. \( \overline{z} = \)
   1) \( z \)  2) \(-z\)  3) \( a - bi \)  4) \( b - ai \)  5) NOT

2. If \( \overline{z}^2 = z^2 \), then \( z \) is
   1) real  2) imaginary  3) real or imaginary
   4) zero  5) NOT
   answer 3

3. If \( \overline{z} = -z \), then \( z \) is
   1) real  2) imaginary  3) real or imaginary
   4) zero  5) NOT
   answer 2

4. \( \overline{z} + z \) is
   1) real  2) imaginary  3) real or imaginary
   4) zero  5) NOT
   answer 1

5. \( z \cdot \overline{z} \) is
   1) positive  2) negative  3) non-negative
   4) complex  5) NOT

6. \( \frac{z - \overline{z}}{i} \) is
   1) real  2) imaginary  3) real or imaginary
   4) zero  5) NOT
   answer 1

7. For what values of \( b \) is \( (b+3i) + (5-bi) = \overline{b+3i} + \overline{5-bi} \)?
8. Express the following in the form $a + bi$

a) $\frac{5 - 2i}{4 - 3i}$

b) $\frac{2i}{2 - i}$

c) $\frac{2 - i}{2i}$

d) $2 - 3i - \frac{(i-1)^2}{1-i}$

answers a) $\frac{26}{25} + \frac{7i}{25}$ d) $1 - 2i$ c) $-\frac{1}{2} - i$

9. Let $D_f = 0$. Find the zeros of the following functions:

a) $f(z) = 3iz - 4$

b) $f(z) = (2-i)z + 5$

c) $f(z) = (3-2i)z - i + 3$

answers a) $-\frac{4i}{5}$ c) $-\frac{11}{12} - \frac{3i}{12}$

10. Calculate the area of the following figure.

11. If $f(z) = z^2 - z + i$, then $f(f(1+i)) =$

12. $5 + i(\frac{3+i}{2-i})^2 =$

answer 3
Assignment 45
Graphical Representation
Of Complex Numbers

1. Plot the following points on the coordinate systems given (with unit circle as reference) and label the argument and absolute value of each.

   a) $1 - \sqrt{3}i$
   b) $1 + i$
   c) $-\sqrt{3} - i$

   \begin{align*}
   \text{answers:} & \quad \text{a) } \frac{5\pi}{3}, 2 \quad \text{c) } \frac{7\pi}{6}, 2
   \end{align*}

2. Express each of the following in the form $a + bi$ and graph it.

   a) $2\text{cis}\frac{3\pi}{4}$
   b) $3\text{cis}\frac{3\pi}{2}$
   c) $2\text{cis}\left(-\frac{7\pi}{6}\right)$

   \begin{align*}
   \text{answers:} & \quad \text{a) } -\sqrt{2} + \sqrt{2}i \quad \text{c) } -\sqrt{3} + i
   \end{align*}

3. Which of the following are equal to $|z|$?

   1) $|z - \bar{z}|$
   2) $|-z|$
   3) $|\bar{z}|$
   4) $|iz|$
   5) $|z - \bar{z}|$
   6) $|z(\text{cis } \Theta)|$
   7) $|\bar{z}|$

   \begin{align*}
   \text{answers:} & \quad 2, 3, 4, 6, 7
   \end{align*}

4. When is $|z|$?

   a) negative
   b) zero
5. Find the product of
   a) $16 \cis \frac{2\pi}{3}$ and $\frac{3}{4} \cis \frac{\pi}{4}$
   b) $12 \cis \frac{\pi}{5}$ and $3 \cis 25^\circ$
   answers a) $12 \cis \frac{11\pi}{12}$  b) $36 \cis 55^\circ$

6. Find the quotient of the numbers in a) and b) above.
   Let the second number be the divisor.
   answers a) $\frac{64}{3} \cis \frac{5\pi}{12}$  c) $4 \cis 5^\circ$

7. Calculate the following in two forms: 1) $a + bi$ and 2) $r \cis \theta$
   a) $(4-4i)(2+2i)(-1+i)$
      b) $\frac{6 \cis \frac{5\pi}{3}}{2\sqrt{3} + 2i}$
   answers a) $-16 + 16i$, $16\sqrt{2} \cis (3\pi/4)$

8. The graph of $|z| = 2$ is best represented by
   1) (1)
      2) (2,0)
      3) 1
      4) 1
      5) NOT
      answer 1

9. The graph of $|z - \bar{z}| = 4$ is (use the choices from 8)
Assignment 46  
Roots Of Complex Numbers

1. Express the results of the following in the form \( r \text{ cis } \theta \).
   a) \((\text{cis } 35^\circ)^6\)  
   b) \((-1 + i)^8\)  
   c) \((1 + \sqrt{3} \text{ i})^9\)

   answers  
   a) \(1 \text{ cis } 210^\circ\)  
   b) \(512 \text{ cis } 3\pi \text{ or } 512 \text{ cis } \pi\)

2. Show that if \( u \in \{x^6 = 1\} \), then \( \bar{u} \in \{x^6 = 1\} \). Graph the solution set.

3. If \( z^3 = 1 \), then \( z \) could be (more than one answer is possible)
   1) \(-1\)  
   2) \(-i\)  
   3) \(\text{cis } \frac{4\pi}{3}\)  
   4) \(\frac{\sqrt{2}}{2} \text{ cis } 120^\circ\)  
   5) NOT

4. If \( z^3 = -i \), then \( z \) could be (more than one answer is possible)
   1) \(i\)  
   2) \(-i\)  
   3) \(\text{cis } \frac{7\pi}{6}\)  
   4) \(\text{cis } 330^\circ\)  
   5) NOT

   answers  
   1, 3, 4

5. Graph the roots of the following equations
   a) \(z^5 = -1\)  
   b) \(z^4 = -i\)

6. Express the following in the form \( a + bi \).
   a) \(\sqrt{-8i}\)  
   b) \(-\sqrt{16i}\)

   answer  
   a) \(2 - 2i\)

7. Find the zeros of the following functions
   a) \(f(z) = z^2 + 16\)  
   b) \(f(z) = 3z^2 - 12i\)

   answer  
   a) \(4i, -4i \text{ or } 4 \text{ cis}(\pi/2), 4 \text{ cis}(3\pi/2)\)

8. True or False: \(\sqrt{ab} = \sqrt{a} \sqrt{b}\) over \(C\). Illustrate.
Assignment 79  Inverse Functions

1. Let $f(x) = 3^x$. Then $f^{-1}(x) =$
   1) $x^3$  2) $\log_3 x$  3) $\log_x 3$  4) $y^3$  5) NOT
   answer 2

2. If $f(x) = 2x + 4$, then $f^{-1}(x) =$
   1) $2y + 4$  2) $4x + 2$  3) $\frac{1}{2}x - 2$  4) $x + 2$  5) NOT
   answer 3

3. If $f^{-1}(x) = 2 - 3x$, then $f(x) =$
   1) $3 - 2x$  2) $\frac{1}{3}(2-x)$  3) $2 - 3x$  4) $3x - 2$  5) NOT

4. If $f(z) = z^4$, then $f^{-1}(z) =$
   1) $\sqrt[4]{z}$  2) $z^2$  3) $\sqrt[4]{z}$  4) $z\sqrt[4]{z}$  5) NOT
   answer 5

5. Sketch the graphs of $f$ and $f^{-1}$ on the same coordinate axes for each of the following:
   a) $f(x) = \frac{1}{2}x + 1$

   b) $f^{-1}(x) = x^3$
6. Express each of the following in the form \( a + bi \).

a) \( 3 \, \text{cis} \left( \frac{5\pi}{3} \right) \)

b) \( (1 - \sqrt{3} \, i)^6 \)

c) \( 10 \, \text{cis} \, \theta \), where \( \theta = \sin^{-1}(3/5) \)

Answers
a) \( \frac{3}{2} + \frac{3\sqrt{3}}{2}i \)
b) 32 or 32 + 0i
c) 8 + 6i

7. Let \( f^{-1}(q) = q^3 \). Then \( f(q) = \)

1) \( \sqrt[3]{q} \)
2) \( q^{3/2} \)
3) \( q^{2/3} \)
4) \( q^2 |q| \)
5) NOT

Answer 1

8. Find a function which is its own inverse.
Assignment 80  Inverse Functions For The Sine And Cosine Functions

1. Arccsin $\frac{\sqrt{2}}{2}$ =
   1) $\frac{\sqrt{2}}{2}$  2) $3\pi/4$  3) $-\pi/4$  4) $9\pi/4$  5) NOT
   answer 5

2. $\cos^{-1}(1/2) + \sin^{-1}(-1/2) =$
   1) 0  2) $\pi/6$  3) $\pi/2$  4) $2\pi/3$  5) NOT

3. Sketch the graphs of the following equations
   a) $y = \sin(\sin^{-1}x)$  
   b) $y = \sin^{-1}(\sin x)$

4. $\sin^{-1}2x =$
   1) $2\sin^{-1}x$  2) $2\sin^{-1}x \cos^{-1}x$  3) $\frac{1}{2}\sin^{-1}x$
   4) $\sqrt{1-(\cos^{-1}2x)^2}$  5) NOT
   answer 5

5. $\sin(\sin^{-1}a + \cos^{-1}b) =$
   1) $a + \sqrt{1 - b^2}$  2) $b + \sqrt{1 - a^2}$  3) $a+b+\sqrt{1-b^2} + \sqrt{1-a^2}$
   4) $ab + \sqrt{(1-b^2)(1-a^2)}$  5) NOT

6. $\sin^{-1}(-y) =$
   1) $-\sin^{-1}y$  2) $\sin^{-1}y$  3) $\frac{\pi}{2} - \sin^{-1}y$
   4) $\pi - \cos^{-1}y$  5) NOT
Assignment 81  Inverse Functions For The Tangent
And Cotangent Functions

1. \( \cot^{-1}\sqrt{3} = \)
   1) \( \sqrt{3} \)  2) \( \pi/6 \)  3) \( \pi/3 \)  4) \( \pi/2 \)  5) NOT

   answer 2

2. \( \tan(\cot^{-1}x) = \)
   1) \( x \)  2) \( 1/x \)  3) \( \sqrt{1-x^2} \)  4) \( \sqrt{x^2-1} \)  5) NOT

   answer 2

3. \( \cot(\cot^{-1}x) = \)
   1) \( x \)  2) \( 1/x \)  3) \( \sqrt{1-x^2} \)  4) \( \sqrt{x^2-1} \)  5) NOT

4. \( \cos(\sin^{-1}x) = \)
   1) \( x \)  2) \( 1/x \)  3) \( \sqrt{1-x^2} \)  4) \( \sqrt{x^2-1} \)  5) NOT

   answer 3

5. The graph of \( y = \tan(\tan^{-1}x) \) is best represented by

   1)  
   2)  
   3)  
   4)  
   5) NOT
Assignment 82  Trigonometric Equations

1. Solve the following trigonometric equations and choose the correct answer from the column to the right. (k is an integer)

   a) $\sqrt{2} \cos x - 2 = 0$
      1) $\left\{\frac{\pi}{4} + \frac{k\pi}{2}\right\}$
      2) $\{k\pi\}$
      3) $\left\{\frac{1}{2}, \frac{1}{2}\right\}$

   b) $\cos^2 x - \sin^2 x + \sqrt{3} \sin x = 1$
      4) $\left\{\frac{\sqrt{3}}{2}, \frac{-\sqrt{3}}{2}\right\}$
      5) $\left\{\frac{\pi}{4} + 2k\pi\right\}$

   c) $\sin(2t+\pi) = \sqrt{2} \cos t$
      6) $\{\frac{\pi}{2} + k\pi\} \cup \left\{\frac{5\pi}{4} + 2k\pi\right\}$
      7) $\{k\pi\} \cup \left\{\frac{3\pi}{2} + 2k\pi\right\}$

   d) $\cos x + \sqrt{3} \sin x = 1$
      8) $\{\frac{\pi}{2} + 2k\pi\}$
      9) $\{\frac{3\pi}{2} + 2k\pi\}$

   e) $2 \sin x + 2 \cos x = 4$
      10) $\{2k\pi\} \cup \left\{\frac{2\pi}{3} + 2k\pi\right\}$
      11) No Solution Exists

   f) $(2 \sin^{-1} x)^2 = \frac{\pi^2}{9}$
      12) NOT

   answers 11, 7, 6, 10, 11, 3
2. \( \cos^{-1}\left(\frac{-\sqrt{3}}{2}\right) = \)

1) \(-\sqrt{3}/2\)  2) \(5\pi/6\)  3) \(-\pi/6\)  4) \(-\pi/3\)  5) NOT

answer 3

3. Arctan(-1) =

1) \(\sqrt{3}\)  2) \(-\pi/4\)  3) \(3\pi/4\)  4) \(7\pi/4\)  5) NOT

answer 2

4. If \(6 \sin^2 t - 3 = 0\), then \(t\)

1) \(\left\{ \frac{\pi}{4} + \frac{k\pi}{2} \right\} \)  2) \(\left\{ \frac{\pi}{4} + 2k\pi \right\} \)  3) \(\left\{ \frac{3\pi}{4} + k\pi \right\} \)  4) \(\left\{ \frac{\pi}{4} + 2k\pi \right\} \cup \left\{ \frac{7\pi}{4} + 2k\pi \right\} \)  5) NOT

answer 1
APPENDIX C

MATHEMATICS STUDY HABITS QUESTIONNAIRE
MATHEMATICS STUDY HABITS QUESTIONNAIRE

NAME___________________ INSTRUCTOR_________________
TIME__________________ COURSE_____________________

ANSWER ALL QUESTIONS ON THIS SURVEY IN CONNECTION WITH YOUR STUDYING OF MATHEMATICS

I. Rank the following as you see them as contributing to your understanding of mathematics; 1-most important, 2-next important, and 3-least important.

_______ Reading the text
_______ Doing the homework
_______ Attending lecture

II. Place the letter of the most appropriate answer in the answer column to the right.

1. Excluding test scores, I judge my standing in class on
a) how well I do on my homework assignments
b) how well I understand my readings
c) how well I follow the lectures

2. When I study, I
a) have the radio, record player, or television on
b) require complete silence
c) am in a room where others sometime distract me

3. When doing homework, I rely mainly on what I learned
a) in lecture
b) by reading the text
c) from previous mathematics courses

4. I study
a) by myself
b) with only one other student
c) with more than one other student
5. I start my homework assignments
   a) as soon as possible after lecture
   b) the latest possible time before the next lecture
   c) other

6. I do my homework
   a) all at one time
   b) with infrequent interruptions
   c) without a set pattern

III. In each of the following situations, you are asked to rate yourself on a 5-point scale: H (Hardly ever), S (Sometimes), F (Frequently), U (Usually), and A (Almost always). Fill in the circle which best describes the situation for you.

   1. When studying for an examination, I arrange my material in some logical order.
   2. Even though I may not like mathematics, I work very hard at it.
   3. I outline the main points of my notes from lecture and from my readings.
   4. I stick with my assignment even if it is dull and boring to me.
   5. I copy the examples and diagrams my instructors place on the chalkboard.
   6. When I get behind in my assignments for some reason, I make up the back assignments on my own.
   7. I am easily distracted from my studies by day-dreaming of more important or pressing things.
   8. I use my homework assignments as a guide for the amount of studying I should do.
   9. I lay aside homework assignments and returned examinations without checking to see what my errors are.
   10. I do not feel that I have time to, or should take the time to, do all of my mathematics homework.
H (Hardly ever), S (Sometimes), F (Frequently), U (Usually), and A (Almost always)

11. When reading the text, I skip over examples, tables, and graphs. 0 0 0 0 0
12. When checking my assignments and exams, I find that my own carelessness is my biggest downfall. 0 0 0 0 0
13. I do my assignments regularly each day as they are assigned. 0 0 0 0 0
14. I do poorly on mathematics tests because that is the first time I am confronted with all the material at one time. 0 0 0 0 0
15. I do not seem to accomplish much in relation to the amount of time I spend studying mathematics. 0 0 0 0 0
16. When reading the text, my mind wanders and I am unable to recall much of what I have just read. 0 0 0 0 0
17. By organizing my work at the beginning, I get the most out of my study time. 0 0 0 0 0
18. I memorize definitions, rules, proofs, formulas, etc. without really understanding them. 0 0 0 0 0
19. The hardest part of doing my assignments is getting myself mentally set to start. 0 0 0 0 0
20. I do not work any harder than I feel I have to in order to receive a passing grade. 0 0 0 0 0
21. I feel that my grades are an accurate description of my ability in mathematics. 0 0 0 0 0
22. I do well on my assignments, but for some reason I do not do as well on examinations. 0 0 0 0 0
23. I hesitate to ask my instructors to explain an assignment or example that is not clear to me. 0 0 0 0 0
24. I start each new mathematics course with a dread of impending doom. 0 0 0 0 0
H (Hardly ever), S (Sometimes), F (Frequently), U (Usually),
and A (Almost always)

25. I use my homework assignments as the primary source for studying for examinations.
    0 0 0 0 0

26. I do not see any relevance in the mathematics I study as to what I plan to do.
    0 0 0 0 0
APPENDIX D

ACHIEVEMENT TEST
Directions: On the answer sheet provided choose the one best response to each of the following questions. "None" means "NONE of the preceding is true."

1. The solution set of \( \frac{x+1}{|x-1|} > 0 \) is
   a) \((-1,1) \cup (1,\infty)\)   b) \((-1,\infty)\)   c) \((1,\infty)\)   d) \((\infty,-1) \cup (1,\infty)\)   e) none

2. \( \frac{xy-x^2}{x-2} = \)
   a) \(2y-x\)   b) \(x-2y\)   c) \(x+2y\)
   d) \(\frac{xy}{x+2y}\)   e) none

3. For \(a < 0, \sqrt[3]{|a|} = \)
   a) \(a^{3/2}\)
   b) \(a^{3/4}\)
   c) \(\sqrt[4]{a^3}\)
   d) \(\sqrt[3]{a}\)
   e) none

4. The solution set of \((x+2)(x-1) \leq 0\) is
   a) \([-2,1]\)
   b) \((-\infty,1]\)
   c) \((-\infty,-2] \cup [1,\infty)\)
   d) \([-2,1]\)
   e) none

5. \(\frac{\sqrt{5} + 1}{\sqrt{2} - 1} = \)
   a) \(1 + \frac{8}{\sqrt{5}}\)
   b) \(\frac{3}{2} + \frac{3}{6\sqrt{5}}\)
   c) \(1 + \frac{1}{\sqrt{5}}\)
   d) \(\frac{4}{2} + \frac{1}{\sqrt{5}}\)
   e) none

6. The domain of \(f(x) = \sqrt{\frac{2-x}{x}}\) is
   a) \((-\infty,2]\)
   b) \([2,\infty)\)
   c) \((-\infty,0) \cup (0,2]\)
   d) \((-\infty)\)
   e) none

7. Which of the following ( (a, (b, (c, or (d ) is not a one-to-one function?
   a) \(\{(x,y)/ y = (x-2)^2\}\)
   b) \(\{(x,y)/ 3 \log_2 x + 1 = y\}\)
   c) \(\{(x,y)/ y = -\sqrt{1-x^2}, x \in [0,1]\}\)
   d) \(\{(x,y)/ |2^x| + 1 = y\}\)
   e) All of the preceding are 1-1

8. \(\log_9 3 = \)
   a) \(\log_4 2\)
   b) 2
   c) \(1/3\)
   d) \(\log_{1/9} 3\)
   e) none
9. The equation of the line through the points (-1,1) and (3,0) is
   a) \( y = 12-4x \)  
   b) \( 4y = 3-x \)  
   c) \( 2y = x-3 \)  
   d) \( y = 4x-12 \)  
   e) none

10. The distance between the points (-1,1) and (3,0) is
   a) \( \sqrt{5} \)  
    b) 17  
    c) \( \sqrt{10} \)  
    d) \( \sqrt{17} \)  
    e) none

11. If \( f(x) = \sqrt{1-x^2} \) over the domain \([-1,0]\) then
   a) \( f^{-1}(x) = \sqrt{1-x^2} \)  
   b) \( f^{-1}(x) = 1-x^2 \)  
   c) \( f^{-1}(x) = \sqrt{x^2-1} \)  
   d) \( f^{-1}(x) \) is undefined  
   e) none

12. Which of the following graphs best represents \( \{(x,y)/ y = 2 - |x|\} \)?

   a)  
   b)  
   c)  
   d)  
   e)  

13. \( \cos 220^\circ = \)
   a) \( \cos 40^\circ \)  
   b) \( \cos 22\pi \)  
   c) \( \cos \frac{11\pi}{18} \)  
   d) \( \cos \frac{11\pi}{36} \)  
   e) none

14. Which of the following is true?
   a) \( \sin 3 > \sin 4 \)  
   b) \( \cos(-1) < \cos 1 \)  
   c) \( \sin 2^\circ \)  
   d) \( |\sec t| < 1 \)  
   e) all of these are true

15. If \( \cos x = \frac{2}{5} \), then \( |\cos 2x| = \)
   a) \( \frac{24}{25} \)  
   b) \( \frac{7}{25} \)  
   c) \( \frac{6}{5} \)  
   d) \( \frac{9}{25} \)  
   e) none
16. In the right triangle at the right, 
\[ x = \begin{align*} 
\text{a)} & \ a \cos \alpha \\
\text{b)} & \ a \sin \alpha \\
\text{c)} & \ a \cot \alpha \\
\text{d)} & \ a \tan \alpha \\
\text{e)} & \ \text{none} 
\end{align*} \]

17. \[ \sin(\cos^{-1} \frac{x}{2}) = \begin{align*} 
\text{a)} & \ \frac{1}{2} \\
\text{b)} & \ \frac{\sqrt{5}}{2} \\
\text{c)} & \ \sin(\frac{\pi}{2}) \\
\text{d)} & \ \frac{\sqrt{5}}{2} \\
\text{e)} & \ \text{none} 
\end{align*} \]

18. \[ \frac{\sin 2t}{\sin t} - \frac{\cos 2t}{\cos t} = \begin{align*} 
\text{a)} & \ \sin t - \cos t \\
\text{b)} & \ 0 \\
\text{c)} & \ \sec t \\
\text{d)} & \ \cos t - \sec t \\
\text{e)} & \ \text{none} 
\end{align*} \]

19. The graph of \( y = -\frac{1}{2} \sin(2x - \frac{\pi}{2}) \) is best represented by 
\[ \begin{align*} 
\text{a)} & \ \\
\text{b)} & \ \\
\text{c)} & \ \\
\text{d)} & \ \\
\text{e)} & \ 
\end{align*} \]

20. \[ (3 + 4i) - (6 - 2i)(1 - i) = \begin{align*} 
\text{a)} & \ 7 - 4i \\
\text{b)} & \ -1 \\
\text{c)} & \ -1 + 12i \\
\text{d)} & \ -5 - 4i \\
\text{e)} & \ \text{none} 
\end{align*} \]

21. \[ \frac{1}{1 - 1} = \begin{align*} 
\text{a)} & \ 1 + i \\
\text{b)} & \ -1 + i \\
\text{c)} & \ 1 - i \\
\text{d)} & \ -i \\
\text{e)} & \ \text{none} 
\end{align*} \]

22. \[ \left[ 3 \left( \cos \frac{\pi}{2} + i \sin \frac{\pi}{2} \right) \right]^4 = \begin{align*} 
\text{a)} & \ 81 \left( -\frac{1}{2} - \frac{i\sqrt{3}}{2} \right) \\
\text{b)} & \ 81 \left( \frac{1}{2} - \frac{i\sqrt{3}}{2} \right) \\
\text{c)} & \ 12 \left( -\frac{\sqrt{3}}{2} - \frac{i}{2} \right) \\
\text{d)} & \ 81 \left( -\frac{\sqrt{3}}{2} - \frac{i}{2} \right) \\
\text{e)} & \ \text{none} 
\end{align*} \]
APPENDIX E
MATHEMATICS OPINIONNAIRE (ATTITUDE)
MATHEMATICS OPINIONNAIRE

Directions: Each statement below expresses a feeling which a particular person has toward mathematics. You are asked to express the extent to which you personally agree or disagree with the opinion stated, on a 5-point scale: SA (Strongly Agree), A (Agree), U (Undecided), D (Disagree), and SD (Strongly Disagree). Fill in the circle at the right indicating the extent of your agreement with the feeling expressed.

1. I feel at ease with mathematics
   SA A U D SD
   0 0 0 0 0

2. When I hear the word mathematics, I have a distinct feeling of dislike.
   SA A U D SD
   0 0 0 0 0

3. I do not feel sure of myself in mathematics.
   SA A U D SD
   0 0 0 0 0

4. Mathematics is a subject I feel I can sink my teeth into.
   SA A U D SD
   0 0 0 0 0

5. Mathematics makes me feel uncomfortable, uneasy, irritable and impatient.
   SA A U D SD
   0 0 0 0 0

6. Mathematics is something which I enjoy doing a great deal.
   SA A U D SD
   0 0 0 0 0

7. Mathematics is fascinating and fun for me.
   SA A U D SD
   0 0 0 0 0

8. I enjoy the challenge of mathematics problems.
   SA A U D SD
   0 0 0 0 0

9. I feel under a great strain in a mathematics class.
   SA A U D SD
   0 0 0 0 0

10. I approach mathematics with a feeling of hesitation.
    SA A U D SD
    0 0 0 0 0

11. Mathematics is stimulating to me.
    SA A U D SD
    0 0 0 0 0

12. Mathematics is my most dreaded subject.
    SA A U D SD
    0 0 0 0 0

13. I have a definite favorable reaction to mathematics: it's enjoyable.
    SA A U D SD
    0 0 0 0 0

14. Working with mathematics is fun.
    SA A U D SD
    0 0 0 0 0

15. It scares me to have to take mathematics.
    SA A U D SD
    0 0 0 0 0
16. At present, I would rate my general attitude toward math as favorable. 0 0 0 0 0

17. Mathematics is very interesting to me. 0 0 0 0 0

18. When I approach my mathematics work, I experience a sense of fear of not being able to do it. 0 0 0 0 0

19. I have a feeling of insecurity when attempting mathematics. 0 0 0 0 0

20. Mathematics is a subject in school which I have liked and enjoyed studying. 0 0 0 0 0

21. The feeling I have toward math is a positive feeling. 0 0 0 0 0

22. Math makes me feel as though I'm lost in a jungle and can't find my way out. 0 0 0 0 0
APPENDIX F

HOMEWORK OPINIONNAIRE
Homework Opinionnaire

Instructor______________ Time________

1. The homework assignments had
   a) too few problems   b) too many problems
c) about the correct amount of problems

2. The homework problems adequately covered the material of the course
   a) seldom   b) sometimes   c) most of the time

3. Did you like the way the homework problems were presented?
   Yes ____________   No ____________

4. Did you use the homework problems in review?
   Yes ____________   No ____________

5. If you answered Yes to question 4, did you use the assignments to review
   a) every week   b) after every section
c) before exams   e) other (specify)

6. On the reverse side of this paper, please make any comments you wish about the treatment of homework for this course. This will help us in future course design.
7. Do you feel that the way your homework assignments were presented contributed more to your understanding of the course than the 'usual' (assigning directly from the text) method would have?

Yes_______ No_______

COMMENTS:
APPENDIX G

MIDTERM EXAMINATIONS AND ANSWER SHEETS
DIRECTIONS: On the answer sheet provided, choose the one best response to each of the following questions by marking with PENCIL ONLY in the appropriate space after the question number. NOT means "none of these".

In questions 1, 2, and 3, \( P \) is the set of positive integers, \( Z \) is the set of integers, \( A = \{ x/ x \in Z \text{ and } x < 3 \} \) and \( B = \{ x/ x \in P \text{ and } x \leq 3 \} \).

1. The set \( B \) is equal to: a) \( (0,3] \) b) \( [0,3] \) c) \( \{1,2,3\} \) d) \( (0,2] \) e) NOT

2. \((A \cap P) \cup B = \) a) \( P \) b) \( \{0,1,2,3\} \) c) \( A \) d) \( B \) e) NOT

3. \( B \cup \{ Z \cap [-1,3)\} = \) a) \( \{1,2\} \) b) \( \{1,2,3\} \) c) \( [-1,3] \) d) \( [-1,3] \) e) NOT

4. \(([-2,5] \cap [5,6)) \cup [-1,5) = \) a) \( [-2,5] \) b) \( [-1,5] \) c) \( [-1,5] \) d) \( [-2,5) \) e) NOT

5. The sum of the solutions to \(|x - 2| = 4\) is: a) \(-6\) b) \(0\) c) \(-4\) d) \(2\) e) NOT

6. \( \sqrt[3]{-164} = \) a) \(2\) b) \( (64)^{2/3}\) c) \(-2\) d) undefined e) NOT

7. If \( a(0, a \in R^1 \) then \( \frac{\sqrt{a^2}}{a^2} = \) a) \(-1\) b) \(1\) c) \(a\) d) \(1/a\) e) NOT

8. Which axiom is used to factor \( yx^2 + yz^2 = y(x^2 + z^2) \)? a) Associative Axiom b) Distributive Axiom c) Inverse Axiom d) Commutative Axiom e) NOT

9. \( \{ x/ \left| x^2 - 1 \right| = 1 - x^2 \} = \) a) \((-\infty, \infty)\) b) \((-1,1)\) c) \((\infty, -1) \cup (1, \infty)\) d) \(\emptyset\) e) NOT
10. If \( x > 0 \) then \( \frac{1 + \sqrt{x}}{1 - \frac{\sqrt{x}}{1 + \sqrt{x}}} = \)

a) \(-\sqrt{x}\)  
b) \(1 + \sqrt{x}\)  
c) \(\frac{1}{1+\sqrt{x}}\)  
d) \(1-x\)  
e) NOT

11. The solution set for \( 1 - 3x \leq 4x + 15 \) is:

a) \(\{x/ x \geq -2\}\)  
b) \(\{x/ x \leq -14\}\)  
c) \(\{x/ x \geq -14\}\)  
d) \(\{x/ x \leq \frac{16}{7}\}\)  
e) NOT

12. \(\{x/ \sqrt{\frac{2-x}{x} \text{ is a real number}}\}\) is:

a) \(\{x/ x \neq 0\}\)  
b) \(\{x/ x \leq 2\}\)  
c) \(\{x/ x \leq 2, x \neq 0\}\)  
d) \(\{x/ -2 \leq x \leq 2, x \neq 0\}\)  
e) NOT

13. \(\{x/ (x - 2)(x + 1) \leq 0\}\) is:

a) \([-2,1]\)  
b) \([-1,2]\)  
c) \((\infty,-1) \cup (2,\infty)\)  
d) \((-\infty,-2) \cup (1,\infty)\)  
e) NOT

14. The solution set for \(|3 - 2x| \leq 1\) is:

a) \([0,1]\)  
b) \([0,1]\)  
c) \([-1,2]\)  
d) \([1,2]\)  
e) NOT

15. The solution set for \(x^2 \geq 5x\) is:

a) \([0,5]\)  
b) \((-\infty,-5) \cup (5,\infty)\)  
c) \([5,\infty)\)  
d) \((-\infty,0) \cup (5,\infty)\)  
e) NOT

16. The solution set for \(|x + 1| < -1\) is:

a) \((-2,0)\)  
b) \((-\infty,-2) \cup (0,\infty)\)  
c) \([5,\infty)\)  
d) \(\emptyset\)  
e) NOT
17. The solution set for \( \frac{x + 1}{|x - 1|} > 0 \) is:
   a) \((-1, 1) \cup (1, \infty)\) b) \((-1, \infty)\) c) \((1, \infty)\)
   d) \((-\infty, -1) \cup (1, \infty)\) e) NOT

18. \( \{x/ -3 < x < 5\} = \{x/ |x - a| < p\} \) where
   a) \(a = -3, p = 8\) b) \(a = 3, p = 8\) c) \(a = -1, \)
   d) \(a = 1, p = 4\) e) NOT

19. For \(a > 0\), \(\sqrt[3]{a^2}\)
   a) \(a^{3/2}\) b) \(a^{3/4}\) c) \(\sqrt[4]{a}\) d) \(\sqrt[3]{a}\) e) NOT

20. The solution set for \(|x| + |x + 3| \leq 3\) is:
   a) \([0, 6]\) b) \(\{0\}\) c) \([0, 3]\) d) \([-3, 0]\)
   e) NOT
Rework any of the problems that you did not do correctly.

1. c
2. d
3. e
4. b
5. e
6. c
7. a
8. b
9. e
10. d
11. a
12. c
13. b
14. d
15. e
16. d
17. a
18. d
19. b
20. d
Midterm II
Math 150
Name

Directions: On the answer sheet provided, choose the one best response to each of the following questions by marking with PENCIL ONLY in the appropriate space after the question number. NOT means "none of these".

1. If \( f(x) = \lceil x \rceil \), then \( f(1/2) = \)
   a) -1  b) 0  c) 1/2  d) 1  e) NOT

2. If \( g(t) = \sqrt{1 - t} \) and \( f(x) = 1 + x^2 \), then \( f(g(-1)) = \)
   a) -1  b) 0  c) 1  d) 2  e) NOT

3. Which of the following (a), (b), (c), or (d) is not a function?
   a) \( \{(x,y)/ y = \left| 3^x \right| \} \)
   b) \( \{(x,y)/ y = \left| x^2 - 1 \right| \} \)
   c) \( \{(x,y)/ y = \left| x \right| \} \)
   d) \( \{(x,y)/ y = \log_2 \left| x \right|, x \neq 0 \} \)
   e) All of the preceding are functions

4. Which of the following graphs best represents \( \{(x,y)/ y = \left| x + 1 \right| \}. \)
   a) 
   b) 
   c) 
   d) 
   e) 

5. If \( f(x) = \sqrt{3-x} \), then the understood domain of \( f \) is:
   a) \([3, \infty)\)  b) \((-3,3)\)  c) \((-\infty,3]\)
   d) \((-\infty,-3] \cup [3,\infty)\)  e) NOT
6. Which of the following best represents \((x,y)/ y = 3-x^2\)
   a) \[\text{Graph a)}\] b) \[\text{Graph b)}\] c) \[\text{Graph c)}\]
   d) \[\text{Graph d)}\] e) \[\text{Graph e)}\]

7. Which of the following best represents \((x,y)/ y \leq |x|\)
   a) \[\text{Graph a)}\] b) \[\text{Graph b)}\] c) \[\text{Graph c)}\]
   d) \[\text{Graph d)}\] e) \[\text{Graph e)}\]

8. The sum of the zeros of \(f(x) = x^2 + 2x - 99\) is:
   a) -2     b) -1     c) 20     d) 2     e) NOT

9. The equation of the line containing the points \((-1,0)\) and \((1,4)\) is:
   a) \(y = 4(x-1)\)     b) \(y = 1\)     c) \(y - 1 = \frac{1}{2}x\)
   d) \(y = 2(x + 1)\)     e) NOT
10. If \( x \) is directly proportional to \( y \) and \( x = 6 \) when \( y = 8 \), then when \( y = 20 \), \( x = \)
   a) 18  b) \( \frac{22}{3} \)  c) \( \frac{26}{3} \)  d) 15  e) NOT

11. If \( y \) is inversely proportional to \( x^2 \) and \( y = 4 \) when \( x = 3 \), then the constant of proportionality equals:
   a) 36  b) 12  c) 4/3  d) 4/9  e) NOT

12. If \( f(x) = \log_2 x^2 \), then the understood domain of \( f \) is:
   a) \((0, \infty)\)  b) \([2, \infty)\)  c) \((-2, 2)\)
   d) \((-\infty, 0) \cup (0, \infty)\)  e) NOT

13. If \( f(x) = 3^{x-1} \), then the range of \( f \) is:
   a) \([3, \infty)\)  b) \((0, \infty)\)  c) \([1, \infty)\)  d) \((-\infty, \infty)\)  e) NOT

14. If \( P = (2, -1) \) and \( Q = (-1, 3) \), then the distance \( PQ \) is:
   a) \( \sqrt{29} \)  b) 1  c) \( \sqrt{5} \)  d) 5  e) NOT

15. If \( b^{x^3} = b(2x)^2 \), then \( x = \)
   a) 0 or 4  b) 0 or 2  c) -1 or 1  d) 2  e) NOT

16. \( \log_8 4 = \)
   a) 2  b) \( \frac{2}{3} \)  c) \(-\frac{1}{2}\)  d) \( \frac{3}{2}\)  e) NOT

17. If \( \log_b 8 = \frac{3}{4} \), then \( b = \)
   a) 6  b) 16  c) 8  d) \( \frac{2}{3}\)  e) NOT

18. If \( f(3) = 4.7 \) and \( f(6) = 6.5 \), then \( f(5) = \)
   a) 5.3  b) 5.6  c) 5.9  d) 6.2  e) NOT

19. Solve: \( x^2 - x + 1 < 0 \)
   a) \( \left( \frac{1-\sqrt{5}}{2}, \frac{1+\sqrt{5}}{2} \right) \)  b) \((0, 1)\)  c) \( \emptyset \)  d) \((-\infty, \infty)\)  e) NOT

20. The solution set for \( \log_3(x+17) = 2 + \log_3(x+1) \) is
   a) \{-17\}  b) \{9\}  c) \{1\}  d) \{-1\}  e) NOT
Rework any of the problems that you did not do correctly.

1. b
2. e
3. e
4. b
5. c
6. d
7. a
8. a
9. d
10. d
11. a
12. d
13. b
14. d
15. a
16. b
17. b
18. c
19. c
20. c
Midterm III Math 150

Name ____________________

Directions: On the answer sheet provided, choose the one best response to each of the following questions by marking with PENCIL ONLY in the appropriate space after the question number. NOT means "none of these".

1. \( \cos\left(\frac{4\pi}{3}\right) = \)
   a) \(-\frac{\sqrt{3}}{2}\) b) \(-\frac{1}{2}\) c) \(\frac{1}{2}\) d) \(\frac{\sqrt{3}}{2}\) e) NOT

2. \( \csc(-90^\circ) = \)
   a) 0 b) 1 c) -1 d) undefined e) NOT

3. \( \cos 3\) =
   a) \(\sin 3\) b) \(\sin(\pi-3)\) c) \(\sqrt{1-\sin^2 3}\) d) \(\cos(-3)\)
   e) NOT

4. \( \cos 200^\circ = \)
   a) \(\cos\frac{5\pi}{9}\) b) \(\cos 20^\circ\) c) \(\cos\frac{10\pi}{9}\) d) \(\sin 70^\circ\)
   e) NOT

5. Which of the following statements is true?
   a) \(\cos 2 > \cos 2^\circ\) b) \(|\sin 2| > |2|\) c) \(\sin 2 < \sin 4\)
   d) \(\sin\frac{3\pi}{4} < \sin\frac{3\pi}{5}\) e) NOT

6. A sector is generated in a circle of radius 3 by a central angle of 15°. The arc length of the sector is
   a) \(\pi/4\) b) \(\pi/6\) c) \(\pi/3\) d) \(\pi/5\) e) NOT

7. If \(\cos x = 2/3\), then \(|\cos(x - \frac{\pi}{2})| = \)
   a) 1/3 b) 2/3 c) \(\sqrt{5/3}\) d) \(\sqrt{5/9}\) e) NOT
8. \( \cos \frac{2\pi}{3} = \)
   a) \( \sin(4\pi/3) \)  b) \( \sin^2(\pi/4) \)  c) \( \cos(4\pi/3) \)
   d) \( \sin(-\pi/3) \)  e) NOT

9. In the right triangle shown, \( x = \)
   a) \( a \sin \alpha \)  b) \( a \csc \alpha \)  c) \( a \tan \alpha \)
   d) \( a \sec \alpha \)  e) NOT

10. \((\sin x - \cos x)^2 + \sin 2x = \)
    a) \( \sin x \)  b) \( 0 \)  c) \( \cos 2x \)  d) \( 1 \)  e) NOT

11. In the triangle shown at the right, \( \sin \alpha = \)
    a) \( \frac{y}{x} \sin \beta \)  b) \( \frac{x}{y} \cos \beta \)  c) \( xy \sin \beta \)
    d) \( \frac{y}{x} \sin \beta \)  e) NOT

12. \((2+3i)(3-i) - (-5+2i) = \)
    a) \( 14+5i \)  b) \( 8+5i \)  c) \( 14+2i \)  d) \( 8+2i \)  e) NOT

13. The solution set of \( \cos t = -1 \) is
    a) \{\pi\}  b) \{t/ t=k\pi, k an integer\}  c) \{\pi, 0, -\pi\}
    d) \{(2k+1)\pi/ k an integer\}  e) NOT

14. \( \{x/ \cos^2 x = \cos x\} \cap [0, 2\pi] = \)
    a) \{0, 2\pi\}  b) \{0, \pi/2, \pi, 3\pi/2, 2\pi\}  c) \{0\}
    d) \{0, \pi/2, 3\pi/2, 2\pi\}  e) NOT

15. \((i+1)^{12} = \)
    a) \( 64 \)  b) \(-64 \)  c) \( 64i \)  d) \(-64i \)  e) NOT
16. The argument of the trigonometric form of $3\sqrt{3} - 3i$ is
   a) 6   b) $5\pi/4$   c) $5\pi/3$   d) $11\pi/6$   e) NOT

17. $\sin(-t)\sec(-t) - \tan(-t) =$
   a) $\sin^2 t \tan t$   b) $1 + \tan t$   c) $2 \tan t$
   d) 1   e) NOT

18. Which of the following is a fourth root of $-8 - 8\sqrt{3}i$
   a) $4\text{cis}\frac{2\pi}{3}$   b) $4\text{cis}\frac{\pi}{3}$   c) $2\text{cis}\frac{\pi}{3}$   d) $2\text{cis}\frac{2\pi}{3}$   e) NOT

19. The graph of $y = -2 \sin 3x$ is
   a)   b)   c)   d)   e)

20. The graph of $\{(x, y) / x = \cos(t - \frac{\pi}{2}), y = \sin t, 0 \leq t \leq \pi/2\}$ is
   a)   b)   c)   d)   e)
Answer Sheet for Midterm III  Math 150

Rework any of the problems that you did not do correctly.

1. b
2. c
3. d
4. c
5. d
6. a
7. d
8. c
9. b
10. d
11. a
12. a
13. d
14. d
15. b
16. d
17. e
18. c
19. e
20. b
APPENDIX H

FINAL EXAMINATION
Math 150

Final Examination

Directions: On the answer sheet provided choose the one best response to each of the following questions. "None" means "NONE of the preceding is true."

1. The solution set of \( \frac{x+1}{x-1} > 0 \) is
   a) \((-1,1) \cup (1,\infty)\)
   b) \((-1,\infty)\)
   c) \((1,\infty)\)
   d) \((\infty,-1) \cup (1,\infty)\)
   e) none

2. \( \frac{x+y-1-4x-1-y}{2x-1+y-1} = \)
   a) \(2y-x\)
   b) \(x-2y\)
   c) \(x+2y\)
   d) \(\frac{xy}{x+c}\)
   e) none

3. For \( a < 0, \sqrt{a^2a} = \)
   a) \(a^{3/2}\)
   b) \(a^{3/4}\)
   c) \(\sqrt[4]{a^3}\)
   d) \(\sqrt[a^3]{a}\)
   e) none

4. The solution set of \((x+2)(x-1) \leq 0\) is
   a) \([-2,1]\)
   b) \((\infty,1]\)
   c) \((\infty,-2] \cup [1,\infty)\)
   d) \((-2,1]\)
   e) none

5. \(\sqrt[5]{x} + \frac{1}{x} = \)
   a) \(1 + \frac{1}{2\sqrt[5]{2}}\)
   b) \(\frac{3}{2} + \frac{1}{2\sqrt[5]{2}}\)
   c) \(1 + \frac{1}{2\sqrt[5]{2}}\)
   d) \(\frac{3}{2} + \frac{1}{2\sqrt[5]{2}}\)
   e) none

6. The domain of \( f(x) = \frac{\sqrt{2-x}}{x} \) is
   a) \((-\infty,2]\)
   b) \([2,\infty)\)
   c) \((-\infty,0) \cup (0,2]\)
   d) \((-\infty,\infty)\)
   e) none

7. Which of the following \((a, (a, (b, (c, or (d) is not a one-to-one function?\)
   a) \((x,y)/ y = (x-2)^2\)
   b) \((x,y)/ 3 \log_2 x + 1 = y\)
   c) \((x,y)/ y = -\sqrt{1-x^2}, x \in [0,1]\) \)
   d) \((x,y)/ |2^x| + 1 = y\)
   e) All of the preceding are 1-1

8. \(\log_5 3 = \)
   a) \(\log_4 2\)
   b) \(2\)
   c) \(1/3\)
   d) \(\log_1/9^3\)
   e) none
9. The equation of the line through the points (-1,1) and (3,0) is  
   a) $y = 12-4x$  
   b) $4y = 3-x$  
   c) $2y = x-3$  
   d) $y = 4x-12$  
   e) none

10. The distance between the points (-1,1) and (3,0) is  
   a) $\sqrt{5}$  
   b) 17  
   c) $\sqrt{10}$  
   d) $\sqrt{17}$  
   e) none

11. If $f(x) = \sqrt{1-x^2}$ over the domain $[-1,0]$ then  
   a) $f^{-1}(x) = \sqrt{1-x^2}$  
   b) $f^{-1}(x) = 1-x^2$  
   c) $f^{-1}(x) = \sqrt{x^2-1}$  
   d) $f^{-1}(x)$ is undefined  
   e) none

12. Which of the following graphs best represents  
   $\{ (x,y) / y = 2 - |x| \}$ ?

13. $\cos 220^\circ$  
   a) $\cos 40^\circ$  
   b) $\cos \frac{22\pi}{18}$  
   c) $\cos \frac{11\pi}{18}$  
   d) $\cos \frac{11\pi}{30}$  
   e) none

14. Which of the following is true?  
   a) $\sin 3 > \sin 4$  
   b) $\cos(-1) < \cos 1$  
   c) $\sin 2^\circ$  
   d) $|\sec t| < 1$  
   e) all of these are true

15. If $\cos x = \frac{3}{5}$, then $|\cos 2x| =$  
   a) $\frac{24}{25}$  
   b) $\frac{7}{25}$  
   c) $\frac{6}{5}$  
   d) $\frac{9}{25}$  
   e) none
16. In the right triangle at the right,
   \( x = \) a) \( \cos \alpha \) b) \( \sin \alpha \) c) \( \cot \alpha \) d) \( \tan \alpha \) e) none

17. \( \sin(\cos^{-1} \frac{2}{3}) = \) a) \( \frac{1}{3} \) b) \( \frac{\sqrt{5}}{3} \) c) \( \sin(\frac{2}{3}) \)
d) \( \frac{\sqrt{5}}{3} \) e) none

18. \( \frac{\sin 2t}{\cos 2t} = \) a) \( \sin t - \cos t \) b) 0 c) \( \sec t \) d) \( \cos t - \sec t \) e) none

19. The graph of \( y = -\frac{1}{2}\sin(2x - \pi) \) is best represented by
   a) \)
   b) \)
   c) \)
   d) \)
   e) \)

20. \( (3 + 4i) - (6 - 2i)(1 - i) = \) a) \( 7 - 4i \) b) \( -1 \) c) \( -1 + 12i \) d) \( -5 - 4i \) e) none

21. \( \frac{i}{1 - i} = \) a) \( 1+i \) b) \( -1+i \) c) \( 1-i \) d) \( -i \)

22. \( [3(\cos \frac{\pi}{3} + i \sin \frac{\pi}{3})]^4 = \) a) \( 81(- \frac{1}{2} - i\frac{\sqrt{3}}{2}) \) b) \( 81(\frac{1}{2} - i\frac{\sqrt{3}}{2}) \) c) \( 12(- \frac{\sqrt{3}}{2} - i\frac{1}{2}) \) d) \( 81(- \frac{\sqrt{3}}{2} - i\frac{1}{2}) \) e) none
23. \( \sqrt{-2^2 + \sqrt{16}} = \)
   a) 2  b) -2  c) undefined  d) 0  e) none

24. \( \{x/ a < x < b\} = \{x/ |x-2| < 1\} \); therefore
   a) a = -\( \frac{1}{2} \), b = \( \frac{1}{2} \)  b) a = -3, b = 3  c) a = 1, b = 3  d) a = -1, b = 3  e) none

25. If \( f(x) = \lfloor x \rfloor \), \( g(x) = x^2 \), then \( g(f(3/2)) = \)
   a) 3/2  b) 1  c) 9/4  d) 2  e) none

26. \( \{x/ b^x = b^{-2x-1}, x is a real number\} = \)
   a) \( \{1\} \)  b) \( \{-1\} \)  c) \( \{1+\sqrt{2},1-\sqrt{2}\} \)  d) \( \emptyset \)  e) none

27. Which of the following graphs best represents \( \{(x,y)/ y = \log_2(x-1)\} \)
   a) 
   b) 
   c) 
   d) 
   e) 

28. If \( \log_b2 = a, \log_b3 = c, \) and \( \log_b5 = d, \) then \( \log_b25\sqrt{3} = \)
   a) ac+d  b) 2d+\( \frac{1}{2}c \)  c) \( d^2+\sqrt{c} \)  d) \( \frac{1}{2}(d^2+c) \)  e) none

29. \( \tan^{-1}(\cos x) = 0 \) if \( x = \)
   a) 0  b) 1  c) \( \pi \)  d) \( \pi/2 \)  e) none

30. \( 1 + \tan^2(\pi/6) = \)
   a) 4/3  b) 1/2  c) 6/5  d) 4  e) none
31. In the triangle at the right, $b$ equals
   a) $\csc \alpha \sin \beta$   b) $\sin \alpha \sin \beta$
   c) $a^2 - a \cos(\alpha - \beta)$   d) $\sin(\theta - \alpha)$
   e) none

32. Using $\pi/12 = \pi/3 - \pi/4$, $\cos(\pi/12) =$
   a) $\frac{\sqrt{2} - \sqrt{6}}{4}$   b) $\frac{\sqrt{6} - \sqrt{2}}{4}$
   c) $\frac{-\sqrt{2} - \sqrt{6}}{4}$
   d) $\frac{\sqrt{6} + \sqrt{2}}{4}$
   e) none

33. The graph of $y = \sin^{-1}(x) - \frac{\pi}{2}$ is
   a) b) c) d) e) none

34. $(3 - i)z = 1 - i$; so $z =$
   a) $\frac{2 - i}{5}$   b) $\frac{1 - 2i}{5}$
   c) $\frac{1}{2}$   d) $\frac{3 - i}{1 + i}$
   e) none

35. $i^2 =$
   a) $-1$   b) $1$   c) $0$
   d) all of these   e) none

36. $\sqrt{3} + i =$
   a) $\sqrt{2}(\cos \frac{\pi}{6} + i \sin \frac{\pi}{6})$
   b) $2(\cos \frac{\pi}{6} + i \sin \frac{\pi}{6})$
   c) $\sqrt{2}(\cos \frac{\pi}{2} + i \sin \frac{\pi}{2})$
   d) $2(\cos \frac{\pi}{2} + i \sin \frac{\pi}{2})$
   e) none
37. \(2(\cos \frac{5\pi}{6} + i \sin \frac{5\pi}{6}) = \)
   a) \(-1 + i \sqrt{3}\)  b) \(-\sqrt{3} + i\)  c) \(1 - i \sqrt{3}\)
   d) \(\sqrt{3} - i\)  e) none

38. \((1 + i)^3 = \)
   a) 1  b) 8 + 8i  c) 16  d) 1 + i  e) none

39. \(8^{1/3} = \)
   a) 2  b) \{2, -1 + i\sqrt{3}, -1 - i\sqrt{3}\}
   c) \{2, 1 + i\sqrt{3}, -1 - i\sqrt{3}\}  d) \{2, -1 + i\sqrt{3}\}
   e) none

40. \((\tan \frac{\pi}{4} - i \cot \frac{\pi}{4})^3 = \)
   a) \(-1 + i\)  b) \(1 - i\)  c) \(-1 - i\)  d) \(-2(1 + i)\)
   e) none
APPENDIX I

PROBLEMS FROM PILOT STUDY
3 pts ea) 1a) Which of the following are subsets of \( M_2 \)?

1) \( M_2 \)  
2) \( N_9 \)  
3) \( M_{18} \)  
4) \( \{0,9,18,\ldots\} \)  
5) \( W \)

1b) Which of the following are subsets of \( M_1 \)?

1) \( M_2 \)  
2) \( M_{10} \)  
3) \( N_9 \)  
4) The set of counting numbers  
5) \( W \)

1c) Which of the following are subsets of \( M_5 \)?

1) \( M_3 \)  
2) \( M_1 \)  
3) \( M_{10} \)  
4) \( W \)  
5) None of these

3 pts ea) 2. Write the largest subset of \( D=\{2,3,4,5,8,9,10\} \) for which each of the following numbers is a mult-of its elements.

a) 276

b) 4,347

c) 18,000

d) 83

e) 726

4 pts ea) 3a) \( M_0 = \)

1) \( W \)  
2) \( \emptyset \)  
3) \( \{0\} \)  
4) The set of counting numbers  
5) None

3b) \( M_1 \)

1) \( W \)  
2) \( \emptyset \)  
3) \( \{1\} \)  
4) the set of counting numbers  
5) None

4 pts ea) 4a) The complement of \( M_2 \) in \( W \) is

1) \( M_1 \)  
2) \( M_0 \)  
3) \( W \)  
4) \( \emptyset \)  
5) None of these

4b) The usual names for \( M_2 \) and \( \text{comp } M_2 \) are
1) the set of even numbers and the set of odd numbers
2) the multiples of 2 and the multiples of odd numbers
3) the set of prime numbers and the set of composite numbers
4) the set of even counting numbers and the set of odd counting numbers
5) 1) and 4)

4c) Choose the "best" answer; $M_2$ and comp $M_2$ are ______
   1) exclusive  2) mutually exclusive and exhaustive
   3) finite      4) exhaustive, but not exclusive
   5) neither exclusive nor exhaustive

4 pts ea) 5a) True or False "Every set $M_b$ is an infinite set".

5b) If true, give an example of a set $M_b$ with $b$ odd;
If false, modify the statement so that it becomes a true statement.

4 pts ea) 6a) Define $M_3$ and $M_4$ in an English sentence.

6b) $M_3 \cap M_4$ in $M_b$ symbolism is
   1) $M_3$  2) $M_4$  3) $M_{12}$  4) $M_7$  5) None of these

3 pts) 7a) $M_2 \cap M_3 =$
   1) $M_2$  2) $M_3$  3) $M_5$  4) $M_6$  5) None of these

3 pts) 7b) $M_2 \cap M_6 =$
   1) $M_2$  2) $M_6$  3) $M_{12}$  4) $M_4$  5) None of these

6 pts) Define the set intersection $M_2 \cap M_b$ (There are three main cases depending on the choice $b$)

4 pts) 8a) Show that $M_4 \cap M_b = M_{20}$

3 pts) 8b) The set of values of $b$ for which $M_{20} = M_4 \cap M_b$ is
   1) $\{5\}$  2) $\{b/b=5n: n\in\mathbb{N}\}$  3) $5, 10, 20$  4) $\{5, 20\}$  5) None

3 pts) 8c) The set of values of $b$ for which $M_{16} = M_2 \cap M_b$ is
8 pts) 9. Explain why it is not possible to decide whether a number is a multiple of 8 merely by examining its last two digits.

10. To determine whether a number is divisible by 2 (i.e., that the number is a multiple of 2) only the last digit of the number need be examined. To decide whether a number is divisible by 4 (2x2 4), the number formed by the last two digits is examined. To determine divisibility by 8 (2x2x2 = 8), the number formed by the last three digits is examined.

5 pts) Decide if either 214, 272 or 216, 272 is divisible by 16.

5 pts) State a rule for deciding whether a number is divisible by $2^n$. 
1) List the eight smallest numbers in each of the following sets.
   a) $M_6$  
   b) $M_1$  
   c) $M_5$

2) Test each of the following numbers to find whether it is a multiple of 2, 3, 4, 5, 8, 9, or 10.
   a) 276  
   b) 4,347  
   c) 18,000  
   d) 726

3) Identify and describe $M_0$ and $M_1$.

4) a) Define the complement of $M_2$ in $W$.
   
   b) The sets $M_2$ and $\text{comp } M_2$ are usually referred to by special names to distinguish them from other subsets of $W$. What are these special names?
   
   c) Are $M_2$ and $\text{comp } M_2$ exhaustive? exclusive?

5) Consider the statement, "Every set $M_b$ is an infinite set". Answer a or b.
   a) If the statement is true, give an example of a set $M$ where $b$ is odd.
   
   b) If the statement is false, modify it so that it becomes a true statement.

6) a) Define the set intersection $M_3 \cap M_4$ in an English sentence.
   
   b) Rename this same set in $M_b$ symbolism.

7) a) Define the set intersection $M_2 \cap M_3$.
   
   b) Define the set intersection $M_2 \cap M_6$.
   
   c) Define the set intersection $M_2 \cap M_b$.

   NOTICE: In c) there are three main cases depending on the choice of $b$.

8) a) Show that $M_4 \cap M_5 = M_20$
   
   b) Find all the values of $b$ for which $M_{20} = M_4 \cap M_b$.
   
   c) Find all the values of $b$ for which $M_{16} = M_2 \cap M_b$. 
9. Why is it not possible to decide whether a number is a multiple of 8 merely by examining the last two digits of the number?

10. To determine whether a number is divisible by 2 (i.e. that the number is a multiple of 2) only the last digit of the number need be examined. To decide whether a number is divisible by 4 ($2 \times 2 = 4$), the number formed by the last two digits is examined. To determine divisibility by 8 ($2 \times 2 \times 2 = 8$), the number formed by the last three digits is examined.

Decide if either 214,272 or 216,272 is divisible by 16, and try to state a rule for deciding whether a number is divisible by 2.
APPENDIX J

QUESTION FORMS FROM PILOT STUDY

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MATHEMATICS 105 REGISTRATION FORM

Print Name ________________________
(last) (first) (middle)

Class 1 2 3 4 Sex M or F K - 3 4 - 6

Local Address Local Phone

Have you taught elementary school? _____Yes _____No
If yes, how many years? ____________

Are you part of a special teacher-training program? _____Yes _____No
If yes, elaborate on the back of the form.

Partial Schedule

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Mathematics Background:

High School College Courses and Courses Grades: and Grades:
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<td>REC INST</td>
<td>SEX M F</td>
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**PLANNED TEACHING LEVEL**

| K-3 | 4-6 | Undecided | Other (Specify) |

**MATHEMATICS BACKGROUND**

**HIGH SCHOOL COURSES AND GRADES**

**COLLEGE COURSES AND GRADES**

1. Did you find the homework problems adequate?
   - Yes
   - No
   - Undecided

2. Did you like the way the homework problems were presented?
   - Yes
   - No
   - Undecided

3. Do you feel that the way your homework assignments were presented contributed more to your understanding of the course than the 'usual' (assigning directly from the text)
   - Yes
   - No
   - Undecided

4. Do you feel that you may treat homework assignments differently from the 'usual' when you begin teaching?
   - Yes
   - No
   - Undecided

5. Did you grade your homework assignments to obtain an evaluation of your achievement?
   - Yes
   - No
   - Sometimes

6. What grade do you expect to receive in this mathematics course?
   - A
   - B
   - C
   - D
   - E
1. Bassham, Harrell; Murphy, Michael and Murphy, Katherine. "Attitude and Achievement In Arithmetic," The Arithmetic Teacher. II: (February, 1964) 66-72.


30. Jacobs, Leland B. "What About Homework?" Childhood Education. XXXI (October, 1941) 74-81.


