# A COMPARISON OF STUDENT PERFORMANCE IN A COLLEGE ENGINEERING COURSE BETWEEN TWO LECTURE METHODS: A TAPED RECORDING AND A PRINTED TRANSCRIPTION

By

WOODFIN GRADY HARRIS, JR.

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1954

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1954

Specialist in Education
Indiana University
Bloomington, Indiana
1963

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
July, 1971

A COMPARISON OF STUDENT PERFORMANCE IN A
COLLEGE ENGINEERING COURSE BETWEEN
TWO LECTURE METHODS: A TAPED
RECORDING AND A PRINTED
TRANSCRIPTION

Thesis Approved:

Kenneth St. Clair
Thesis Adviser

A. Stephens Higgins

Gene L. Post

Harry E. Heath, Jr.

D. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The writer wishes to express his appreciation and sincere thanks to his committee chairman, Dr. J. Kenneth St. Clair, for his advice and encouragement throughout the preparation and completion of this thesis. Special gratitude is due to the writer's committee; Dr. Gene L. Post, Dr. A. Stephen Higgins and Dr. Harry E. Heath, Jr., for their guidance and constructive criticisms during the stages of preparation of this thesis.

Gratitude is extended to Dr. Kenneth A. McCollum for allowing the writer to perform this investigation in the College of Engineering. I am indebted to Dr. Thomas A. Dean for his suggestions in the pre-study planning. To Dr. Allen E. Kelly, the writer extends a special thanks for his efforts and consultation in the collection of data and for allowing his sections of engineering science to be the focus of this study.

To my wife and Margaret Estes, I am indebted for their typing and clerical assistance in the preparation of this manuscript.

To Andrew J. Armstrong and all others who have been of assistance, directly and indirectly, I extend my sincere appreciation.

# TABLE OF CONTENTS

# LIST OF TABLES

# CHAPTER I

## INTRODUCTION

Many institutions of higher learning, recognizing the effects of ever increasing enrollments and expansion of knowledge, have been turning to innovative methods of teaching. These new teaching methods are being developed and used to maintain acceptable levels or improve the quality of instruction under the stress of modern educational problems. Carpender [6] in making assumptions about the future of American higher education states that:

> 1. The trends of demands will continue and increase, and new and unpredictable demands will be added before 1980.
>
> 2. Traditional methods of operating colleges and universities will become inadequate and the need for a developed technology of education will become apparent.
>
> 3. Expanded and improved research will provide reliable and valid evidence as to the relative advantages and limitations of special parts and systems of instructional technologies.

One instructional technique which has been developed and is in use is the audio-tutorial (see page 12 for definition) method which uses tape recordings to present the information to be learned or procedures for learning. However, it is probable that some instructors have accepted an audio-tutorial system without sufficient investigation to determine if this would be a satisfactory method of efficient instruction. Each subject matter area or course offering will present unique factors to be considered in the evaluation of the audio-tutorial method of instruction.

## Background for Study

The audio-tutorial method of instruction was used by Postlethwait [18] in the instruction of students enrolled in botany at Purdue University. The tape recorder was used to present instructional material to the student and also direct him in performing certain experiments. Postlethwait found no significant difference in student achievement between this method of instruction and the conventional method. Some advantages of this method of instruction became apparent:

1. Students can progress at their own rate.
2. Scheduling is flexible.
3. Staff, time, facilities, and equipment can be redistributed.

Postlethwait and Husband [11] found there were fewer D's and F's and more A's and B's in classes which were taught by the audio-tutorial method. This factor was also supported in studies by Anderson [3] and Schrautemeier and Kottmyer [21].

It is difficult to separate the effects of the method of presentation from the method of preparation in the analysis of this type of instruction. To present a course by the audio-tutorial method, the instructor must prepare each tape with a particular instructional objective or set of objectives in mind.

> Emphasis on student learning rather than on the mechanisms of teaching is the basis of the audio-tutorial approach. It involves the teacher identifying as clearly as possible those responses, attitudes, concepts, ideas, and manipulatory skills to be achieved by the student and then designing a multi-faceted, multi-sensory approach which will enable the student to direct his own activity to attain these objectives [18].

This method of course design has a "programming" effect on the material presented to the learner and thus may present the material in a more learnable package. Mager [13] states that the first step which should precede all other decisions related to choice of methods or materials to be used is the specifying of instructional intent. By organizing his course in terms of behavioral objectives and specifying instructional intent, the instructor can provide the complete course in meaningful programmed packages. The use of techniques such as the audio-tutorial method forces the instructor to perform this analysis and therefore results in a more flexible, meaningful, and efficient use of the students' and the instructor's time.

The audio-tutorial method of instruction can be used in conjunction with sophisticated electronic equipment to provide learning experiences through dial access retrieval systems. This allows the student to have access to a large number of audio learning packages. There are a number of dial access installations in educational institutions such as Oklahoma Christian College of Oklahoma City, Oral Roberts University of Tulsa, Oklahoma, and Oakland Community College of Bloomfield Hills, Michigan. The tape recorded material to be used in a dial access system must be prepared with the same consideration for objectives and instructional intent as in the other audio-tutorial systems. The course objectives and individual tape objectives must be analyzed and used as a basis for the preparation of the lessons. Diagrams, symbols, formulas and related matter cannot be adequately described verbally. Therefore some packages include printed and/or projected materials which the students use in conjunction with the audio learning package.

By adding other means of presenting visual and verbal materials to the audio-tutorial and instructional objectives combination, the instructor may approach a systems method of teaching. Student response and feedback must be considered along with student evaluation, program evaluation, and system revision.

According to Brown, Lewis, and Harcleroad [5], the elements to be considered in preparing materials for a systems approach would include the following:

1. The students.
2. The objectives and content.
3. The methods.
4. The learning experiences.
5. The materials.
6. The facilities.
7. The equipment.
8. The evaluation of results.

The evaluation of results would indicate possible areas which need refining to aid in the redesigning of elements of the system. This refining process should be a "built-in" feature of self improvement for any instructional communications system.

The systems approach to instructional communications is an outcome of the recognizing of the applications of behavioral objectives to instruction and the expansion of educational technology, including the use of the computer.

> A systems approach to instruction implies a scientific study of the kind of instruction required by each learner, the time when it is needed, and the appropriate design, organization, and operation of a system which can achieve behavioral goals. In its broadest sense, an instructional

> system is a set of interrelated components (not aids or adjuncts) in mutual interaction [20].

To support these newer methods of instruction a source of expertise must be available to aid the concerned instructor in the preparation of objectives and materials for his courses. Some institutions of higher learning are beginning to recognize this need and are examining and adopting the concept of the Learning Resources Center. Such centers may have different titles on the various campuses though the total concept is the same. However, the various centers perform different specific functions in fulfilling their role in this concept. Some centers are encompassed in one building while others have satellite centers which have specialized functions.

To support the instructor in his endeavors to improve, expand, or mediate his instruction is the overall aim of most Learning Resource Centers. The services of a modern "center" might well include consultation and aid in:

1. Preparing instructional objectives.
2. Storing information materials for retrieval and use.
3. Preparing and producing non-projected visuals, projected media, audio materials for independent use as well as for coordinated use with projectors or other visual devices, and television materials.
4. Distributing center for audio-visual and library materials.
5. Course evaluation.

## Tape Recording in Instruction

One aspect of this study is concerned with some of the different utilization techniques in adapting taped recordings for teaching.

Techniques reviewed here include teaching groups with phonograph recordings; teaching groups with taped recordings; and teaching groups through individualized instruction using taped recordings. In all but one of these studies the experimental technique or recording is compared to a type of traditional lecture-discussion format of teaching.

At the college level there has been a limited amount of basic research in the use of taped recordings in instruction [2, 22, 17]. Menne [15] states that "... review of literature since 1962 indicated no further investigations have been made of the feasibility of using taped lectures" and very few studies have attempted to assess the effectiveness of direct teaching by taped recording. A search of the Educational Resources Information Center's abstract journal of Research in Education [7] from January, 1967, to September, 1970, seems to extend Menne's statement for the period since his study (Spring, 1969) to the present. There has been some research in the use of taped recordings; however, in these studies the taped recordings were not the prime source of lecture materials.

Prior to the development of the wire and tape recorders the phonograph was "the" audio recording device. Its introduction onto the American scene was received with mixed emotions. John Philip Sousa [14] commented at the time: "With the phonograph vocal exercises will be out of vogue! Then what of the national throat? Will it not weaken? What of the national chest? Will it not shrink?"

McLuhan [14] reacts to Sousa's remarks by stating:

> One fact Sousa had grasped: The phonograph is an extension and amplification of the voice that may well have diminished individual vocal activity, much as the car had reduced pedestrian activity.

The phonograph record, taped recording or other medium is just a "carrier." For the information to be meaningful to human beings the content must be prepared and coded, then received and decoded.

Research into recording as a technique of education has largely taken place since the study by Rulan [19] in the early 1940's. Rulan used phonograph records in the subject matter area of history as the experimental method and a printed playlet as the control method. The study compared the knowledge gain between the two teaching techniques. The results indicated that the playlet was superior in immediate gain but the recordings could possibly be more effective for higher retention scores after a lapse of two or more weeks.

Other studies of recordings have used the tape recorder to present the instructional materials. In most studies, the experimenter has used the tape recorder with a group, but in a later study tapes were used with individuals, each of whom had access to a tape recorder. These studies compared the taped instructional materials-discussion method to the traditional lecture-discussion method of teaching. The results of these studies seem to indicate that there is no significant difference in evaluation scores between the two methods [15, 16, 17].

Popham [17] following an opinion survey presented the following advantages of the taped method:

1. There were fewer distractions and interruptions.
2. Recorded lectures are better organized.
3. Instructor's absence induced a more relaxed atmosphere.

Two disadvantages were:

1. Sometimes taped material moved too fast.
2. Students had no opportunity to ask questions.

Several research studies into the use of taped recordings have been completed recently at Oklahoma State University. These doctoral dissertations were completed during the spring, summer, and fall semesters of 1970.

One study [1], conducted at Oklahoma Christian College approached the problems of the proper length of a taped recorded lecture which could provide the optimum of learning. A fifty minute package of instructional information was designed, recorded and placed on a dial access retrieval system. The subjects were randomly assigned to one of four treatments. The treatments were varied as to the length of presentation. One treatment presented the total package in one fifty minute tape, the other treatments presented the package in two twenty-five minute, three eighteen minute (approximately) and four twelve and one-half minute sessions. The subjects were then administered a forty-eight item multiple choice evaluative instrument.

No significant differences were indicated in amount of information retained due to the subjects' use of the differing listening arrangements. It was concluded, statistically, that the subjects who were assigned the one fifty minute session did no better or no worse on items pertaining to the last twenty-five minutes of the package than the subjects whose treatment allowed them to be less fatigued while listening to that portion of the package. However, based on the mean scores and student responses to an "impact study," it was recommended that the twenty-five or eighteen minute sessions should be considered in the future.

The other studies [4, 9] were concerned with sections of botany classes on the campus of Oklahoma State University. One study investigated the effectiveness of the taped method used in an audio-tutorial system. The audio-tutorial method had been used in this introductory botany course for four years prior to the research [4]. This study did not compare the method of instruction to another method, but compared the achievement of the subjects according to performance as indicated by a pre-test score and a post-test score. There were only two conclusions which indicated significant difference:

1. That a significant gain in achievement was determined for students taught by the audio-tutorial method of instruction.
2. That achievement by females is greater than achievement by males using an audio-tutorial method of instruction.

The latter of these differences does not agree with Weaver's [23] result in which there was no significant difference in achievement between female and male students as indicated by the average of examination scores in an audio-tutorial biology course. "However, this study supports the generally accepted observation that educational achievement by females is greater than that by males" [4].

The other study [9] investigated students' opinions of the tape recorded method of presenting a botany class. The results of this study indicate that, at least in the subject matter area of science, audio-tutorial programming of material seems to favor the female students. The males felt less challenged by this method and thus were less favorable toward it. It was further concluded that:

> ... in attempts to evaluate this program or the projection of new A-T programs it would appear that no problems should be anticipated when considering science vs. non-science majors, classification of students, or whether or not the students have had previous audio-tutorial experience [9].

## Purpose of the Study

Members of the administration at Oklahoma State University have indicated that the improvement of instruction, including the statewide extension program, is an immediate concern. The present audio-tutorial systems on the Oklahoma State campus were initiated to aid in the improvement of instruction. The present systems run the gamut from total taped instruction to supplemental materials and from each individual student with his personal recorder to group listening in the classroom.

The College of Engineering has been offering audio-tutorial courses for the past five semesters. Staff members who are directly involved with these courses have indicated a need to investigate the effectiveness of this instruction. One of the reasons for this concern is that 500 to 600 students are enrolled in these courses each year. For the past five years, the Botany Department at Oklahoma State University has been using taped recordings to supply information and instruction to students in an introductory botany course. There are additional audio-tutorial courses in development in various areas of engineering and in other colleges on the campus. Therefore it is appropriate to conduct basic research in the current use of audio-tutorial methods on the campus.

Engineering Science 2123 (see page 12 for definition), which provides the focus for the present study, is one of the courses taught with the use of taped recordings as the source of lecture material. Each student has a tape recorder available to him. Lectures are duplicated from a master tape onto cassettes or reels so each student will have a copy of the recorded lecture to use at his discretion. These tapes are issued one week before the lecture is given. A printed handout of lecture notes (see page 13 for definition) also is distributed for use with the tape. After the first class session, the student's contact with the instructor is by group dialog and by individual conference at the student's or instructor's request.

## Problem

This study attempted to determine if there is a difference in scores between groups using the tape recorded lecture, the control method, and groups using a printed transcript of the taped lecture, the experimental method. Both the retention of knowledge and the amount of immediate learning are important in this study. Knowledge which can be retained and used at a later date is usually the desired outcome of teaching, not just knowledge for immediate use. Variables such as cumulative college grade-point average, student attitude and engineering major are considered as possible determinants of the results of this study. The analysis of these variables could indicate which had positive or negative effects on the results.

A student's evaluation of the knowledge gained from a lecture may be influenced by many factors. Therefore the student's opinion of a particular method of teaching will not necessarily be an evaluation of the actual effectiveness of the method. An opinion questionnaire was administered to determine the subject's opinion of the treatment assigned to him. The score on the attitude questionnaire was then correlated with the subject's score on the post post-test. These data provided information to aid in determining if the students' opinions, by groups, necessarily correlated with their performance on the post post-test.

The major area of study could affect a student's performance in a course. This would be true in an audio-tutorial course, as well as a course taught by more conventional methods. This effect of major degree emphasis, would be possible if the course content included mathematics, formulas, diagrams and professional jargon.

Travers [22] states that much of the research on the use of audio-visual materials answers only specific questions; therefore, findings should not be treated as general principles. Further, he states that the stimulus must be related to the learner and these in turn should be related to the learning outcomes. This indicates that research into the use of teaching-learning techniques should be localized using instructors, student populations and recognized learning goals unique to a particular locale or institution.

## Definitions

1. Audio-tutorial: A method of instruction which uses a mechanical device to produce audio material which has been prerecorded for use in individual instruction.
2. Engineering Science 2123: A three hour course required of all engineering students at Oklahoma State University. Students may enroll during their sophomore, junior or senior year. The title of the course is "Behavior of Deformable Solids." During this course the students should become familiar with the behavior of steel, concrete and timber when it is subjected to forces.
3. Group Dialog: An open discussion, 50 minutes in length, held weekly between the instructor and the students.

4. Lecture Notes: A printed guide to aid a student in studying the lecture material of a course. The lecture is in a form designed to be distributed to the student. Visual material, which cannot be presented by tape, will be included in these notes.
5. Printed Transcript: A verbatim printed copy of an audio recording.
6. Study Lecture: Class lecture used to gather data for a research study.
7. Tape Cassette: A cassette or enclosure for 1/8 inch magnetic tape permanently affixed at both ends to reels within the enclosure.
8. Taped Recordings: Recording of sound which has been recorded on either a reel or cassette of magnetic tape.

## CHAPTER II

## METHODOLOGY AND DESIGN

### Introduction

This study was conducted to examine the difference in evaluative scores between groups subjected to two methods of teaching and to determine if certain variables could affect the results of either method. The two teaching methods used in this study were tape recorded lectures, the control method, and printed transcripts of the recordings, the experimental method.

### Hypotheses

Data were obtained by using identical taped and printed versions of three lectures in an undergraduate course and evaluation instruments designed to measure differences in knowledge gain immediately following each lesson and another instrument to measure retention of knowledge three weeks following the third evaluation. Statistical analyses were used to measure and analyze the differences in performance by groups and to test the following hypotheses:

> Hypothesis 1: The difference in method of presentation will not differentially influence the scores on the post-test of engineering achievement.
>
> Hypothesis 2: The difference in method of presentation will not differentially influence the scores on the post post-test of engineering achievement.

Hypothesis 3: The difference in past college grade-point average will not differentially influence the scores on the post-test of engineering achievement.

Hypothesis 4: The difference in past college grade-point average will not differentially influence the scores on the post post-test of engineering achievement.

Hypothesis 5: The scores on the post-test will not be significantly influenced by the interaction of past college grade-point average and method of presentation.

Hypothesis 6: The scores on the post post-test will not be significantly influenced by the interaction of past college grade-point average and method of presentation.

## Limitations

This research was conducted in the College of Engineering of Oklahoma State University, a large southwestern land grant university. The data were collected entirely from an undergraduate population enrolled in engineering. Therefore generalizations from this study should be limited to populations which have similar characteristics to those of engineering students attending Oklahoma State University and to this technique of instruction.

The following assumptions were made in analyzing the data obtained in the study.

1. The groups used in this study were randomized by the procedures used to assign subjects to groups.
2. The distributions of groups categorized by treatment and grade-point average were normal.
3. The variance of groups categorized by treatment and grade-point average was the same.
4. The subjects who participated in this study were honest in their responses to both attitude and knowledge instruments.

## Sample

The sample consisted of students enrolled in Engineering Science 2123 for the spring semester 1971. All the sections taught by one instructor were used to provide subjects for this study. A total of 104 students began the study. During the first week, four students dropped the course, resulting in a final total of 100 subjects. This made it possible to include in each of the four cells of the research design a sufficient number of subjects to provide appropriate statistical data. The population contained sophomores, juniors and seniors.

The college grade-point average of each student in the study sections was obtained and then the students were arranged by rank order using the cumulative grade-point average. The median of this distribution was computed and the students whose averages were above the median became the high grade-point average group and the students whose average fell below the median became the low grade-point average group. The students were numbered consecutively from the student with the highest grade-point average, as Number One, to the student with the lowest grade-point average, as Number One Hundred. The numbers were then consecutively designated as pairs, i.e., 1 and 2, 3 and 4, ..., 99 and 100. Within each of these pairs the students were randomly assigned to one of the two treatments.

## Organization of the Study

Each student in this research sample had completed Engineering Science 2113. Engineering Science 2113 is the prerequisite course for Engineering 2123 and is taught through the use of instructional methods identical to those used in 2123. Therefore, the students in Engineering

TABLE I

DESCRIPTION OF GROUPS

| Designation | Group |
|---|---|
| $T_1$ | High grade-point average, control |
| $T_2$ | Low grade-point average, control |
| $T_3$ | High grade-point average, experimental |
| $T_4$ | Low grade-point average, experimental |

Science 2123 were acquainted with the control method, the taped recording method, and had performed satisfactorily in the use of such techniques. Both courses are required for all engineering students.

The first three taped lectures of the course were selected to provide the subject matter material for the study. These study lectures were prepared on magnetic tape and also transcribed onto the printed page. A standard requirement for this course and its prerequisite course is for each student to have personal access to a tape recorder.

At the time of distribution of the printed transcript of the first study lecture the subjects were informed that they were participating in a research study and asked to use only the materials issued to them. Students were given assurance that if, after the experiment was concluded, any student felt that his performance was hindered by the experimental procedure, he could discuss this with his professor. This method of control was discussed with the Assistant Dean of Engineering and the instructor of the study course. It was their opinion that the rapport of the instructor with the students was such that the results of the study would not be affected by intentional contamination by the students.

Students in Group $T_1$, high grade-point average (control), and Group $T_2$, low grade-point average (control), received the lecture materials in a normal manner: taped recordings and printed lecture notes (see Appendix A). Group $T_3$, high grade-point average (experimental), and Group $T_4$, low grade-point average (experimental), received printed lecture transcripts (Appendix B) and printed lecture notes. The four groups were tested (post-test $t_1$, $t_2$, and $t_3$)(Appendix C) over the material contained in each study lecture during the same week in which each lecture was presented. This entailed the preparation of three post-tests.

The total group was evaluated (post post-test) (Appendix D) three weeks following the evaluation of the third post-test, to determine if the passage of time had had an effect on the retention of information. These data were analyzed to determine if there was a significant difference between the two study groups. Certain selected variables were analyzed to see if there is a relationship between the variable and the test scores on retained lecture materials.

The primary variables of this study are the method and the cumulative college grade-point average of each subject. The remaining variables are designated as secondary variables. The secondary variables include:

1. Student attitudes toward an experimental method of instruction.
2. A comparison of performance between the students in various engineering majors on the post post-test.

Appropriate statistical tests were administered to determine if there were any significant differences in scores between treatments, between or within groups on the post-tests, and if there were any significant difference between or within groups on the post post-test. One selected variable, the students' engineering majors, was analyzed to determine if there would be any significant differences between the groups of various engineering majors. A student opinion questionnaire (see Appendix E) was administered after the post post-test to determine if the students' opinions of the methods would agree, by groups, with the results of the students' performance on the post post-test.

## Evaluative Instruments

The instruments used in this study to evaluate knowledge gain were designed by the instructor. The instructor was experienced in the teaching of this course and was familiar with teaching techniques involved. Having designed evaluative instruments for this course material in the past and by consulting with instructors involved in teaching other sections of Engineering Science 2123, the instructor selected the items for use in the post-tests and post post-tests which he judged to be those most valid. The tests contained multiple choice, completion and true-false items. The number of items on each test was as follows: $t_1$ consisted of 25 items, $t_2$ consisted of 33 items, $t_3$ consisted of 18 items and $t_4$ consisted of 42 items. The reliability of these tests was analyzed by using the Rulon split half statistical method.

The opinion questionnaire was developed to be used with a Likert-type rating scale. The opinionnaire contained nine statements which were designated as favorable or unfavorable toward the experimental method used in this study. The statements were selected from statements used in a similar type opinionnaire in a study by John W. Layman [12]. The Likert scale provides a high reliability when using a small number of statements. The reliability of opinionnaires when the researcher uses a Likert-type summated-rating scale, with ten statements, is relatively high and has ranged from .91 to .93. With as few as seven statements, the reliability coefficients had ranged from .77 to .87 [10]. The opinionnaire should contain approximately the same number of statements from each class of statement [8]. The opinionnaire used in this study contains four statements of the favorable class and five statements of the unfavorable class.

## Experimental Design and Statistical Treatment

From the original sample of 104 students ninety-four completed the study with sufficient data to be included in the analysis. This was well in excess of the minimum requirement of forty students needed to provide ten subjects for each of the four cells.

TABLE II

NUMBER OF STUDENTS REMAINING IN GROUPS AT END OF STUDY

| Group | Number of Students |
|---|---|
| $T_1$ | 25 |
| $T_2$ | 21 |
| $T_3$ | 24 |
| $T_4$ | 24 |
| TOTAL | 94 |

Four test scores and one opinionnaire score were to be sought for each student. It was decided that six 2 X 2 factorial designs would be used to determine if there were any significant differences between the primary groups of this study (Table III).

TABLE III

GROUPS AS COMPARED IN ANALYSES

| Analysis | Compared Group | to | Group | on Test |
|---|---|---|---|---|
| 1 | $T_1$ and $T_2$ | | $T_3$ and $T_4$ | $t_1$, $t_2$, $t_3$ |
| 2 | $T_1$ and $T_2$ | | $T_3$ and $T_4$ | $t_4$ |
| 3 | $T_1$ and $T_3$ | | $T_2$ and $T_4$ | $t_1$, $t_2$, $t_3$ |
| 4 | $T_1$ and $T_3$ | | $T_2$ and $T_4$ | $t_4$ |
| 5 | $T_1$ and $T_3$ | | $T_4$ and $T_2$ | $t_1$, $t_2$, $t_3$ |
| 6 | $T_1$ and $T_3$ | | $T_4$ and $T_2$ | $t_4$ |

Twelve randomized data analyses of variance were used to test the differences between engineering-major groups on performance on the post post-test. These analyses tested the difference between these engineering major groups of both experimental and control treatments. The engineering majors represented by the subjects in this study included (number in parentheses indicate number of students in group):

1. Aero Space Engineering (3)
2. Agricultural Engineering (3)
3. Architectural Engineering (3)
4. Architecture (20)
5. Chemical Engineering (12)
6. Civil Engineering (6)
7. Electrical Engineering (22)
8. General Engineering (2)

9. Industrial Engineering (9)

10. Mechanical Engineering (12)

11. Undecided Classification (2)

The majors of a "like nature" were grouped. This provided four groups of engineering majors for the analyses as follows (number in parentheses indicate number of students in group):

1. Architecture-Architectural Engineering (23)

2. Electrical-Chemical Engineering (34)

3. Aero Space-Civil-Mechanical Engineering (21)

4. Agricultural-General-Industrial Engineering (14)

The opinion scores were correlated with the individual experimental scores to determine if students were favorable or unfavorable toward the experimental method. Some remarks, both favorable and unfavorable, were included on some opinionnaires by the students. The opinionnaire was administered to both the experimental and the control groups. The scores of the control groups were not a part of the statistical treatment of this study because these students had had no experience with the experimental method. The comparison of an individual's scores to his remarks on the attitude questionnaire leads to some interesting observations. Especially is this true concerning the comparison of remarks from the students who used the transcripts and those who did not.

# CHAPTER III

## RESULTS OF THE STUDY

### Introduction

The goals of this study were: (1) to compare the performance of students enrolled in an engineering science course using two different instructional methods (2) to investigate the effects of method on attitude and (3) to detect if cumulative grade-point average would interact with method to create a difference. One hundred subjects participated in this study. These subjects were divided into two groups (high and low) according to their cumulative grade-point average. They were then randomly assigned by pairs to one of the two instructional methods used in this study.

The data from the three post-tests provided the scores used to compute the variances for Hypotheses One, Three and Five. The post post-test provided data to compute the variance for Hypotheses Two, Four, Six and the differences between engineering major groups. Presented in Tables IV, V, VI and VII are the raw data for the participants' scores on the three post-tests and the post post-test. The missing numbers in these tables are the numbers for students on which insufficient data were collected due to absences and drop-outs. The mean scores of the four groups on the post-tests and the post post-tests are contained in Table VIII.

TABLE IV

RAW SCORES FOR HIGH GRADE-POINT AVERAGE GROUP (CONTROL)

| Subject Number | Post-Test #1 | Post-Test #2 | Post-Test #3 | Post Post-Test |
|---|---|---|---|---|
| 2 | 21 | 29 | 15 | 37 |
| 4 | 22 | 28 | 13 | 32 |
| 6 | 20 | 29 | 8 | 29 |
| 8 | 22 | 24 | 11 | 31 |
| 10 | 22 | 24 | 14 | 27 |
| 12 | 22 | 20 | 11 | 30 |
| 14 | 18 | 28 | 11 | 26 |
| 16 | 21 | 24 | 14 | 32 |
| 17 | 15 | 24 | 14 | * |
| 19 | 20 | 23 | 17 | 33 |
| 22 | 21 | 23 | 12 | 28 |
| 23 | 20 | 20 | 16 | 28 |
| 25 | 18 | 21 | 12 | 28 |
| 27 | 16 | 23 | 8 | 28 |
| 29 | 23 | 27 | 15 | 34 |
| 31 | 22 | 24 | 11 | 27 |
| 33 | 13 | 29 | 8 | 33 |
| 35 | 18 | 19 | 13 | 25 |
| 37 | 19 | 21 | 12 | 28 |
| 40 | 20 | 23 | 12 | 24 |
| 41 | 13 | * | 7 | 21 |
| 43 | 18 | 23 | 10 | 24 |
| 45 | 17 | * | 11 | * |
| 48 | 14 | 21 | 12 | 29 |
| 50 | 10 | * | 6 | 17 |
| s.d. | 3.05 | 3.12 | 2.80 | 4.42 |
| $\bar{X}$ | 18.60 | 23.95 | 11.72 | 28.30 |

*No response available as the student was absent on the day this instrument was administered.

TABLE V

RAW SCORES FOR LOW GRADE-POINT AVERAGE GROUP (CONTROL)

| Subject Number | Post-Test #1 | Post-Test #2 | Post-Test #3 | Post Post-Test |
|---|---|---|---|---|
| 52 | 20 | * | 6 | 25 |
| 56 | 17 | 18 | 10 | * |
| 58 | 20 | 23 | 12 | 29 |
| 60 | 22 | * | 8 | * |
| 62 | 23 | 20 | 11 | 28 |
| 64 | 20 | 23 | 8 | 33 |
| 66 | 13 | 17 | 10 | 24 |
| 68 | 15 | 22 | 9 | 26 |
| 72 | 15 | 20 | 9 | 32 |
| 74 | 20 | 19 | 7 | 25 |
| 78 | 21 | 19 | 9 | 25 |
| 80 | 18 | 20 | 12 | 28 |
| 82 | 9 | 22 | 5 | 16 |
| 83 | 7 | 18 | 12 | 20 |
| 87 | 19 | * | 7 | * |
| 90 | 21 | 29 | 14 | 33 |
| 92 | 13 | 22 | 8 | 21 |
| 94 | 16 | 15 | 8 | 20 |
| 96 | 13 | 19 | 5 | 20 |
| 98 | 11 | 18 | 8 | 20 |
| 100 | 20 | 26 | 10 | 30 |
| s.d. | 3.15 | 3.34 | 2.40 | 5.05 |
| $\bar{X}$ | 16.81 | 20.56 | 8.95 | 25.28 |

*No response available as the student was absent on the day this instrument was administered.

TABLE VI

RAW SCORES FOR HIGH GRADE-POINT AVERAGE GROUP (EXPERIMENTAL)

| Subject Number | Post-Test #1 | Post-Test #2 | Post-Test #3 | Post Post-Test |
|---|---|---|---|---|
| 1 | 23 | 29 | 16 | 34 |
| 3 | 20 | 31 | 12 | 22 |
| 5 | 21 | 21 | 7 | 29 |
| 7 | 24 | 27 | 11 | 33 |
| 9 | 17 | 26 | 16 | 31 |
| 11 | 23 | 20 | 13 | 36 |
| 13 | 15 | 25 | 14 | 21 |
| 18 | 21 | 22 | * | 27 |
| 20 | 16 | 24 | 15 | 24 |
| 21 | 20 | 27 | 10 | 30 |
| 24 | 17 | 20 | 12 | 25 |
| 26 | 19 | 24 | 14 | 34 |
| 28 | 16 | 22 | 10 | 19 |
| 30 | 23 | 22 | 12 | 26 |
| 32 | 15 | 29 | 11 | 38 |
| 34 | 17 | 23 | 6 | 24 |
| 36 | 17 | 25 | 10 | 26 |
| 38 | 15 | 23 | * | 25 |
| 39 | * | 19 | 12 | 30 |
| 42 | 18 | 20 | 11 | 24 |
| 44 | 17 | 21 | 2 | 21 |
| 46 | 17 | 20 | 13 | 26 |
| 47 | 20 | 17 | 14 | 24 |
| 49 | 19 | 23 | * | 30 |
| s.d. | 1.55 | 3.51 | 3.35 | 5.05 |
| $\bar{X}$ | 18.70 | 23.33 | 11.48 | 27.46 |

*No response available as the student was absent on the day this instrument was administered.

TABLE VII

RAW SCORES FOR LOW GRADE-POINT AVERAGE GROUP (EXPERIMENTAL)

| Subject Number | Post-Test #1 | Post-Test #2 | Post-Test #3 | Post Post-Test |
|---|---|---|---|---|
| 51 | 15 | 22 | 12 | 29 |
| 53 | 20 | 25 | 12 | 24 |
| 55 | 19 | 24 | 14 | 19 |
| 57 | 22 | 25 | 10 | 33 |
| 59 | 19 | 21 | 6 | 25 |
| 61 | 16 | 23 | 13 | 26 |
| 63 | 15 | 27 | 11 | 29 |
| 65 | 16 | 19 | 11 | 24 |
| 67 | 17 | 23 | 9 | 20 |
| 69 | 9 | 15 | 7 | 16 |
| 71 | 19 | 18 | 6 | 21 |
| 73 | 16 | 23 | 12 | 26 |
| 75 | 18 | 25 | 13 | * |
| 77 | 17 | 12 | 8 | 17 |
| 79 | 19 | 22 | 8 | 24 |
| 81 | 21 | 20 | 10 | 13 |
| 84 | 12 | 23 | 7 | 14 |
| 86 | 12 | 19 | 7 | 19 |
| 88 | 11 | 16 | 2 | 18 |
| 89 | 14 | 19 | 7 | 22 |
| 91 | 15 | 14 | 5 | * |
| 95 | 12 | 15 | 12 | 15 |
| 97 | 19 | 16 | 9 | 22 |
| 99 | 10 | 17 | 11 | 21 |
| s.d. | 4.46 | 4.06 | 2.99 | 5.19 |
| $\bar{X}$ | 15.96 | 20.13 | 9.25 | 21.68 |

*No response available as the student was absent on the day this instrument was administered.

TABLE VIII

MEAN SCORES AND STANDARD DEVIATIONS ON
POST-TESTS AND POST POST-TEST

| Group | Post-Test #1 | | Post-Test #2 | | Post-Test #3 | | Post Post-Test | |
|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | s.d. | $\bar{X}$ | s.d. | $\bar{X}$ | s.d. | $\bar{X}$ | s.d. |
| $T_1$ | 18.60 | 3.05 | 23.95 | 3.12 | 11.72 | 2.80 | 28.30 | 4.42 |
| $T_2$ | 16.81 | 3.15 | 20.56 | 3.34 | 8.95 | 2.40 | 25.28 | 5.05 |
| $T_3$ | 18.70 | 1.55 | 23.33 | 3.51 | 11.48 | 3.35 | 27.46 | 5.05 |
| $T_4$ | 15.96 | 4.46 | 20.13 | 4.06 | 9.25 | 2.99 | 21.68 | 5.19 |

Statistical Analysis

> Hypothesis 1: The difference in method of presentation will not differentially influence the scores on the post-test of engineering achievement.

The analysis of variance on each of the post-tests using the method of instruction as the independent variable yielded "F" ratios (Table IX) which did not reach the values necessary for the differences to be significant at the .05 level of confidence with appropriate degrees of freedom for each test. Therefore, the null hypothesis failed to be rejected; the groups did not differ significantly.

TABLE IX

ANALYSIS OF VARIANCE FOR TREATMENT ON POST-TESTS

| Post-Test | SS | df | MS | F | P = .05 |
|---|---|---|---|---|---|
| $t_1$ | 5.46 | 1 | 5.46 | 0.52 | NS |
| $t_2$ | 10.56 | 1 | 10.56 | 0.85 | NS |
| $t_3$ | 0.64 | 1 | 0.64 | 0.08 | NS |

Hypothesis 2: The difference in method of presentation will not differentially influence the scores on the post post-test of engineering achievement.

The analysis of variance on the post post-test using the method of instruction as the independent variable yielded an "F" ratio of 4.56 (Table X), not significant at the .05 level of confidence with one and eighty-three degrees of freedom. Therefore, the null hypothesis failed to be rejected; again the groups did not differ significantly.

TABLE X

ANALYSIS OF VARIANCE FOR TREATMENT ON POST POST-TEST

| Source | SS | df | MS | F | P = .05 |
|---|---|---|---|---|---|
| Treatment | 112.69 | 1 | 112.69 | 4.56 | NS |

> Hypothesis 3: The difference in past college grade-point average will not differentially influence the scores on the post-test of engineering achievement.

The analysis of variance on each of the post-tests using the difference in cumulative grade-point average as the independent variable yielded an "F" ratio (Table XI) which exceeded the values for the differences to be significant at the .05 level. The null hypothesis was rejected due to the levels of confidence shown for the three post-tests (Test 1, < .005; Test 2, < .001; Test 3, < .001). Therefore, as expected, the groups did differ significantly.

TABLE XI

ANALYSIS OF VARIANCE FOR PAST GRADE-POINT AVERAGE ON POST-TESTS

| Post-Test | SS | df | MS | F | P = .05 |
|---|---|---|---|---|---|
| $t_1$ | 121.83 | 1 | 121.83 | 11.62 | < .005 |
| $t_2$ | 242.13 | 1 | 242.13 | 19.39 | < .001 |
| $t_3$ | 141.90 | 1 | 141.90 | 16.76 | < .001 |

> Hypothesis 4: The difference in past college grade-point average will not differentially influence the scores on the post post-test of engineering achievement.

The analysis of variance on the post post-test using the cumulative grade-point average as the independent variable yielded an "F" ratio of 18.63 (Table XII) which exceeded the value necessary for the difference to be significant at the .05 level of confidence with one and eighty-three degrees of freedom. The null hypothesis was rejected at the .001 level of confidence; the groups did, as expected, differ significantly.

TABLE XII

ANALYSIS OF VARIANCE FOR PAST GRADE-POINT AVERAGE ON POST POST-TEST

| Source | SS | df | MS | F | P = .05 |
|---|---|---|---|---|---|
| Grade-Point Average | 451.77 | 1 | 451.77 | 18.63 | < .001 |

> Hypothesis 5: The scores on the post-test will not be significantly influenced by the interaction of past college grade-point average and method of presentation.

The analysis of variance on each of the post-tests using the interaction of variables as the independent variable yielded "F" ratios (Table XIII), not significant at the .05 level of confidence with appropriate degrees of freedom for each test. Therefore, the null hypothesis failed to be rejected; the groups did not differ significantly.

TABLE XIII

ANALYSIS OF VARIANCE FOR INTERACTION ON POST-TESTS

| Post-Test | SS | df | MS | F | P = .05 |
|---|---|---|---|---|---|
| $t_1$ | 3.53 | 1 | 3.53 | 0.34 | NS |
| $t_2$ | -4.23 | 1 | -4.23 | -0.37 | NS * |
| $t_3$ | 1.03 | 1 | 1.03 | 0.12 | NS |

*With multiple post-tests, one is dealing with non-independent measures and the variance is accounted for more than once; since the "F" ratio is less than one, there would be no significant difference.

> Hypothesis 6: The scores on the post post-test will not be significantly influenced by the interaction of past college grade-point average and method of presentation.

The analysis of variance on the post post-test using the interaction effect as the independent variable yielded an "F" ratio of 0.98, not significant at the .05 level with one and eighty-three degrees of freedom. Therefore, the null hypothesis failed to be rejected; again the groups did not differ significantly.

TABLE IV

ANALYSIS OF VARIANCE FOR INTERACTION ON POST POST-TEST

| Source | SS | df | MS | F | P = .05 |
|---|---|---|---|---|---|
| Interaction | 23.73 | 1 | 23.73 | 0.98 | NS |

## Test Reliability

The reliability of the post-tests and post post-test was computed by the use of the Rulon split-half formula. Table XV presents the reliability coefficients for each of the four tests.

TABLE XV

RELIABILITY COEFFICIENTS

| Test | Total Variance | Error Variance | True Variance | Reliability Coefficient |
|---|---|---|---|---|
| Post-Test 1 | 9.90 | 4.06 | 5.84 | .59 |
| Post-Test 2 | 14.77 | 4.81 | 9.96 | .67 |
| Post-Test 3 | 9.84 | 5.28 | 4.56 | .46 |
| Post Post-Test | 29.32 | 7.20 | 22.12 | .75 |

## Comparison of Groups According to Engineering Major

Each of the engineering major groupings was compared to each of the other engineering major groupings on the post post-test scores. Each grouping was further divided into two cells, one contained the data for students who used the experimental method and one contained the data for students who used the control method. The results of the twelve randomized analyses of variance (Table XVI) indicated three differences which were significant at the .05 level or beyond. Each of these significant differences was concerned with the Architecture-Architectural Engineering Group.

TABLE XVI

COMPARISONS OF STUDENT PERFORMANCE ON THE POST POST-TEST
ACCORDING TO ENGINEERING MAJORS

| Major | Experimental | Control |
|---|---|---|
| 1. Architecture-Architectural Engr.<br>vs<br>Electrical-Chemical Engr. | 7.65 < .01<br>+ * | 5.74 < .05<br>+ * |
| 2. Architecture-Architectural Engr.<br>vs<br>Aero Space-Civil-Mechanical Engr. | 3.13 NS<br>+ | 5.55 < .05<br>+ |
| 3. Architecture-Architectural Engr.<br>vs<br>Agricultural-General-Industrial | 2.24 NS<br>+ | 4.67 < .10<br>+ |
| 4. Electrical-Chemical Engr.<br>vs<br>Aero Space-Civil-Mechanical Engr. | .17 NS<br>+ | +<br>1.22 NS |
| 5. Electrical-Chemical Engr.<br>vs<br>Agricultural-General-Industrial | +<br>.034 NS | .055 NS<br>+ |
| 6. Aero Space-Civil-Mechanical<br>vs<br>Agricultural-General-Industrial | .094 NS<br>+ | .10 NS<br>+ |

*The plus signs indicate which of the groupings had the high mean score, although the differences in most cases were not significant.

## Attitude Questionnaire

An attitude questionnaire with a Likert-type scale was administered following the post post-test. Nine statements were classified as favorable or unfavorable toward a treatment. Four points were possible on each question if the subject strongly agreed, for a possible total of thirty-six points; the higher the score, the more favorable the subject's attitude toward the method of instruction assigned to him.

A correlation was computed using the data from the attitude questionnaire scores (Table XVII) to determine if there was a relationship between the subject's performances on the post post-test and his score on the attitude questionnaire.

TABLE XVII

ATTITUDE QUESTIONNAIRE RAW SCORES AND GROUP MEANS

| Group $T_1$ | | Group $T_2$ | | Group $T_3$ | | Group $T_4$ | |
|---|---|---|---|---|---|---|---|
| Subject | Score | Subject | Score | Subject | Score | Subject | Score |
| 2 | 29 | 52 | 20 | 1 | 12 | 51 | 25 |
| 4 | 20 | 54 | * | 3 | 20 | 53 | 15 |
| 6 | 18 | 56 | * | 5 | 26 | 55 | 29 |
| 8 | 23 | 58 | 14 | 7 | 17 | 57 | 26 |
| 10 | 23 | 60 | * | 9 | 30 | 59 | 14 |
| 12 | 26 | 62 | 24 | 11 | 35 | 61 | 5 |
| 14 | 24 | 64 | 13 | 13 | 25 | 63 | 18 |
| 16 | 30 | 66 | 26 | 15 | * | 65 | 27 |
| 17 | * | 68 | 18 | 18 | 26 | 67 | 10 |
| 19 | 25 | 70 | * | 20 | 23 | 69 | 36 |
| 22 | 19 | 72 | 24 | 21 | 23 | 71 | 17 |
| 23 | 26 | 74 | 10 | 24 | 23 | 73 | 19 |
| 25 | 19 | 76 | * | 26 | 25 | 75 | * |
| 27 | 29 | 78 | 22 | 28 | 26 | 77 | 24 |
| 29 | 29 | 80 | 25 | 30 | 25 | 79 | 29 |
| 31 | 29 | 82 | 26 | 32 | 20 | 81 | 27 |
| 33 | 13 | 83 | 11 | 34 | 21 | 84 | 23 |
| 35 | 8 | 85 | * | 36 | 25 | 86 | 27 |
| 37 | 31 | 87 | * | 38 | 10 | 88 | 30 |
| 40 | 23 | 90 | 30 | 39 | 26 | 89 | 25 |
| 41 | 23 | 92 | 23 | 42 | 18 | 91 | * |
| 43 | 24 | 94 | 7 | 44 | 27 | 93 | * |
| 45 | * | 96 | 25 | 46 | 14 | 95 | 24 |
| 48 | 19 | 98 | 25 | 47 | 5 | 97 | 25 |
| 50 | 18 | 100 | 21 | 49 | 16 | 99 | 30 |
| $\bar{X}$ | 22.95 | $\bar{X}$ | 20.22 | $\bar{X}$ | 21.58 | $\bar{X}$ | 22.95 |

*No response available as the student was absent on the day that this instrument was administered.

TABLE XVIII

CORRELATION FOR ATTITUDE SCORES

| Source | N | r | Level | |
|---|---|---|---|---|
| Experimental | 46 | -0.15 | .10 | Not Significant |
| Control | 41 | 0.23 | .10 | Not Significant |

Neither of the correlations yielded a significant value when the Pearson Product-Moment Correlation formula was applied. There was no relationship between the performance on the post post-test and the attitude score as indicated by the statistical analysis. By observing the means obtained by the groups on the attitude questionnaire, one may note that the higher performing subjects using the control method appear to prefer this method more than did the higher performing subjects in the experimental group. The lower performing subjects of the experimental group seemed to prefer the experimental method to a greater degree than did the lower performing subjects of the control group.

# CHAPTER IV

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### Summary

The purpose of this study was to determine if a difference in performance on tests would be observed between groups of students using two different methods of instruction. The control method of instruction (taped lecture) had been used in the prerequisite course. Therefore, the students were familiar with this type of course material. The scores on the post post-test were analyzed to determine if there was any difference between groups of students in the various engineering majors.

The attitudes of the students were sampled to determine if there was a correlation between the student's attitude and his performance on the tests presented to him during the study. If a student felt that the experimental procedures had had a detrimental effect on his grade he could discuss this with the instructor with the possibility of changing his grade. The instructor reported, following the end of the semester, that no requests for "grade discussions" had been received.

A summary of the hypotheses indicated that in all cases, except hypotheses three and four, the null hypothesis was accepted. The "F" ratio obtained in testing these hypotheses, with the exceptions noted, did not reach a level which would allow the rejection of the null hypotheses at the .05 level. This indicated that there were no significant differences in performance scores between groups due to treatments or the interaction of treatments and groups.

Hypotheses Three and Four were concerned with differences due to level. The total sample was ranked by grade-point average, then separated into high and low groups at the median. The level was determined by the students' cumulative grade-point averages. As would be expected those of the high grade-point average group did perform significantly better than those of the low grade-point average group.

## Conclusions

Subject to the limitations of this study, certain inferences and conclusions may be drawn. Although the study did not bring forth any unexpected statistical differences, it is felt that the following conclusions were drawn objectively from the data from all evaluative instruments, informational and attitude, and from the remarks written on the attitude questionnaire by the students.

1. In the organization of Engineering Science 2123, using the present class materials, tapes and lecture notes, there seems to be no difference in performance on tests and retention between these materials and the use of a printed transcript of the lecture tape.
2. According to attitude scores, there is an indication that the high control group did, ever so slightly, prefer the tapes, but one must remember that the students in this group had no contact with the experimental method.
3. There was also a slight indication that the low experimental group did prefer the printed lecture and these students had

contact with the control method in the prerequisite course.

4. The students seemed to read most words in the transcript, but skipped words when listening to the tape. This was indicated by remarks that the transcripts were too long and the extra material should not have been added to the transcript. The transcripts had been copied verbatim from the corresponding recorded tapes.
5. It seems that the subjects in general preferred a combination of the lecture notes and the printed transcripts. However, some indicated that a choice of materials would be an ideal instructional resource.
6. Little difference in performance between engineering major groupings in Engineering Science 2123 was noted when using the printed transcript. This is indicated by the fact that only one of the six comparisons provided a significant difference. The differences were more apparent in the comparisons of engineering major groupings using the taped lectures, as two significant differences were noted at the .05 level and one at the .10 level.
7. It was apparent in Table XVI that the Architecture-Architectural Engineering major grouping did not perform quite as well as the other groupings. This was the case using both methods of instruction and three of the four differences were significant, two at the .05 level and one at the .01 level.
8. There were no significant differences between the three remaining engineering groupings:

   Electrical-Chemical
   Aero Space-Civil-Mechanical
   Agricultural-General-Industrial

These conclusions were drawn from five objectively scored evaluative instruments including one attitude questionnaire. However, at the end of the attitude questionnaire the students were asked to write any remarks about the treatments or the course in general. The next portion of this chapter includes some of these remarks. These statements are divided into two groups. The first group includes the remarks of students from the experimental group and the second group students from the control group. Each set of statements is arranged so that the first statements were from students with the highest cumulative grade-point average.

The following are some quotes from students of the experimental group.

1. It was harder to shift between reading the printed material and the notes at the same time, than to listen to the tapes and use the notes.

2. I had the written lecture, and I was pleased with the convenience. Using these notes, if I had a few spare minutes, I could sit down and read some, perhaps master a concept, without bothering with tape, a player, etc. I would say, however, that a written lecture could be made better by incorporating the tape notes (diagrams, calculations, etc.) into the written lecture.

3. I had the printed transcript and feel that it had many advantages over the tape. Would liked to have had all lessons printed.

4. The tapes are easier to use at present since you follow the notes while listening; a very simple task. However, if the written form was combined with the notes to form one followable text, I'm sure that it would be a vast improvement over the tapes. As it stands though, even though I liked the written tapes, it took too much time to read one thing and look and study another.

5. I can't really tell which method is better, because the notes still need working on. There were too many grammar errors and confusion points in the lectures on paper. I found it easier to concentrate with the tapes.

6. I think the notes I had were helpful to a certain degree. Had the notes been proof-read more carefully, they would have been extremely beneficial. If it be possible, I think both methods (tape and written notes) should be used. In this way, a very good lecture can be prepared for each problem set and put on tape (advantage # 1). Also, the notes would provide excellent reference material. (I think the notes should contain portions from each of the several different reference books list in our packets (advantage # 2).) Finally, I think the weekly lecture should be abandoned. And, the 2 hour "lab" be changed to contain two hours of actual lab demonstrations! ONLY.

7. The written lessons would have been useful if there had not been necessary to refer constantly to figures and equations. I would recommend the method to other types of study besides this.

8. The notes were good but were too long and lost your attention. I was for a printed supplement but in a condenced (sic) version. When you put the same extraneous wording on the notes as the tape, the value is lost.

9. I though that the method of presentation with the notes instead of tapes was much better for me. It is easier to read and remember this material than listen on the tape. You could go back to the notes of the tape any time and find what you were looking for which was (is) not always true with the tapes.

10. My scores are bad anyway but tapes are such a hassle! I really prefer an instructor but I'd rather read and reread than listen and sleep. Tapes are very poor means of education.

The next group of statements is made up of quotes from some of the subjects in the control group. In reading these statements, remember that these subjects were not exposed to the experimental transcripts used in this study.

1. It is absurd to try to use word in print to explain a topic which was originally intended to be audio to supplement the given study notes for the course. There would be too much "cross-referencing" between written guide and notes. That's what a textbook is for!--

2. The tapes and notes were superior to the printed notes because the printed notes had no diagrams. I don't see how anyone could get anything out of the printed

notes since there were no diagrams. If the tapes were transcribed word for word along with the diagrams they would be best. In other words, I don't think you can beat a good text and class lectures with the tapes. The tapes appear to be a fad and a gimmick (I cannot spell) to cover up bad teaching and to get the instructor away from the students. If the class was run with regular lectures and a text with tapes provided in the library as a suppliment (sic) only, you would have something good.

3. The cassettes could be improved to provide a clearer and a "slower" presentation.

4. I am not familiar with the notes method, however, in the tapes, as much emphasis, including explanation should be given to actual problem solution as theory development.

5. Neither method appeared very effective. The tape-notes-problems were inconsistant (sic) and I understand the typed notes were to (sic) time consuming. If a person were able to get help when he needed it it would help. But no one observes their office hours.

6. It seems to me that both methods the tape-note and just note perhaps should be the same. Yet I feel I could have gained more from reading than listening to the tapes. They seem to be an easier reference to the material and high pts. could have been underlined if I had had the notes.

7. I did not have the printed notes but the idea that seemed to come from those that did have the notes is that they could be carried like a book and referred to, where in the case of the taped lectures the tape was listened to once and set aside, or not listened to at all.

8. The written tape was worse, the spoken tape was bad enough. We needed a good text, not those notes. With a good text and 1-2 hrs of lecture +1hr prds. session lab. per week, we would have been ahead.

## Recommendations

Recommendations evolving from this study are categorized under two headings: (1) recommendations to be considered for the course of

Engineering Science 2123 at Oklahoma State University, and (2) recommendations for future research into audio-tutorial techniques in Engineering Science 2123 and in the general area of audio-tutorial instruction at Oklahoma State University.

## Recommendations for Engineering Science 2123, at Oklahoma State University

Findings 1, 2 and 3 were compiled from the students' responses on the attitude questionnaire.

1. The tape lectures should be improved technically to enhance the quality of sound and make the tapes easier to understand. This would allow the student to concentrate more on the material presented and possibly the student would retain a greater portion of the material for a longer period of time.
2. Make all combinations of materials available to the student at his option. Printed transcripts, lecture notes and taped recordings could be available and the student could choose the material which would help him to learn with the least effort in his own learning style.
3. The lecture notes which contained formulas, diagrams, and symbols should be integrated into a printed transcript of the lecture.
4. An alternative for recommendation 3 would be to include more information in the lecture notes. By adding key phrases, descriptions, and verbal explanations to these lecture notes the student could review the instructional material without listening to the tape again.

5. The feasibility of using the tapes only as supplemental material should be studied.

6. In the design of future materials for use in Engineering Science 2123 the inclusion of some visual media should be considered, i.e., 35mm slides or 8mm concept films. These visual media could present actual demonstrations of the principles being discussed and be coordinated with the tape or printed transcripts. A series of slides could be included in the packet of materials covering a particular concept. These slides could visualize a lab demonstration or an on-the-job application of theoretical principles, thus making the total package a more meaningful experience.

7. If, in the future, efficient use of instructor time becomes a factor, a combination of class materials, taped recordings, lecture notes, and printed transcripts might be considered to allow the use of larger lecture sections.

8. One of the advantages of the audio-tutorial method of instruction is the possible self pacing of the student. It would seem advantageous to consider this featrue for use in the future planning of this course. The self pacing concept could also be used if students were given the option of choosing the materials. This would necessitate the reorganizing of both the materials and the personnel involved in teaching Engineering Science 2123. The student would then progress at his own rate and be allowed more flexibility in the completion of the requirements of the course.

Recommendations for Future Research in Audio-Tutorial Instruction

1. This study should be replicated under conditions which would allow a somewhat higher level of control than a field study condition allowed. For example, a situation in which the students were required to attend the testing sessions and the study was organized in such a manner that the data, from the post-tests, could be collected in a shorter period of time. The evaluative instruments would contain only multiple choice items.
2. The lecture notes and an edited version of the printed transcript should be integrated into a single study guide and the study replicated.
3. The study should be replicated over a longer period of time. The time between the last post-test and the final post post-test should be lengthened.
4. The effects of the addition of visual media to an existing course using the audio-tutorial method should be investigated.
5. The effectiveness of the audio-tutorial method across subject matter areas should be investigated to determine if the method of instruction is more effective in some areas than in others.

As mentioned earlier in this report, many of the studies to determine the effectiveness of a method of instruction should be performed in the institution, the school, or in the specific area to which the findings and generalizations are to be made. The differences in populations can vary in many aspects, therefore the findings are applicable only to specific situations and conditions. With these limitations a study of this nature can provide much needed information to support a specific teaching technique or course organization. It can indicate possible directions for the improvement of a teaching-learning climate.

Although direct generalizations to other populations usually cannot be stated, indirect assumptions by the reader may prove to be helpful in the improvement of instruction in various teaching learning situations, which may or may not be closely akin to the situation which was investigated in the original study.

# BIBLIOGRAPHY

(1) Alexander, Larry J. "Listening Time as it Relates to Learning Information Presented by Audio Tape On a Dial Access System." (Unpub. Ed. D. dissertation, Oklahoma State University, 1970).

(2) Allen, William H. "Audio-Visual Communication." Encyclopedia of Educational Research, ed. C. W. Harris. New York: Macmillan Co., 1960, pp. 115-137.

(3) Anderson, Jane J. "History of Western Civilization Audio-Tutorial Style." (Unpub. paper, Montgomery College, 1969).

(4) Armstrong, John H. "An Exploratory Study of the Effectiveness of an Audio-Tutorial System as an Instrument of Instruction in an Introductory Botany Course at Oklahoma State University." (Unpub. Ed. D. dissertation, Oklahoma State University, 1970).

(5) Brown, James W., Richard B. Lewis, and Fred F. Harcleroad. AV Instruction: Media and Methods. New York: McGraw-Hill, 1969, 3d ed.

(6) Carpender, C. R. "Toward a Developed Technology of Instruction, 1980." Campus 1980, ed. Alvin C. Eurich. New York: Dell Pub. Co., 1968, pp. 236-253.

(7) Educational Resources Information Center. Research in Education. U. S. Department of Health, Education, and Welfare (Washington, D.C.: Government Printing Office), Vols. 2-5 (1967-1970).

(8) Edwards, Allen L. Technique of Attitude Scale Construction. New York: Appleton-Century-Craft, Inc., 1957.

(9) Frye, Benjamin Moss. "Attitude Toward Science and the Audio-Tutorial Method of Teaching General Botany at Oklahoma State University." (Unpub. Ed. D. dissertation, Oklahoma State University, 1970).

(10) Hall, O. M. "Attitudes and Unemployment." Arch. Psychology, Number 165 (1934), p. 19.

(11) Husband, D. D., and S. N. Postlethwait. "The Concept of Audio-Tutorial Teaching." (Unpub. paper, Purdue University, 1969).

(12) Layman, John Wallace. "An Approach to the Teaching of Introductory Physics in a Large-Group, Non-Laboratory Setting." (Unpub. Ed. D. dissertation, Oklahoma State University, 1970).

(13) Mager, Robert F. Preparing Objectives for Programmed Instruction. San Francisco: Fearon Publishers, 1962.

(14) McLuhan, Marshall. Understanding Media: The Extensions of Man. New York: McGraw-Hill, 1964.

(15) Menne, John J., et al. "Use of Taped Lectures to Replace Class Attendance." Audio Visual Communications Review, Vol. 17, Number 1 (Spring, 1969), pp. 42-46.

(16) Popham, W. James. "Tape Recorded Lectures in the College Classroom II." Audio Visual Communications Review, Vol. 10, Number 2 (March-April, 1962), pp. 94-101.

(17) Popham, W. James. "Tape Recorded Lectures in the College Classroom." Audio Visual Communications Review, Vol. 9, Number 2 (March-April, 1961), pp. 109-118.

(18) Postlethwait, S. N., J. Novak, and H. T. Murray, Jr. The Audio-Tutorial Approach to Learning. Minneapolis: Burgess Pub. Co., 1969, 2d ed.

(19) Rulan, Phillip J., et al. "A Comparison of Phonographic Recordings with Printed Material in Terms of Knowledge Gained Through Their Use Alone." Harvard Educational Review, Vol. 13 (Jan., 1943), pp. 63-76.

(20) Saettler, Paul. A History of Instructional Technology. New York: McGraw-Hill, 1968.

(21) Schrautemeier, B., and W. Kottmyer. "Development of a Multi-Media Approach to the Teaching and Learning of Elementary College Physics." (Unpub. paper, Meramec Community College, 1969).

(22) Travers, Robert M. W., et al. Research and Theory Related to Audiovisual Information Transmission. USOE 3-20-003, Kalamazoo, Michigan: Western Campus Bookstore, 1967.

(23) Weaver, G. M. "An Evaluation and Analysis of Audio-Tutorial Instruction in a General Education Biology Course at El Centro College." (Unpub. Ph.D. dissertation, East Texas State University, 1969).

# APPENDIX A

# LECTURE NOTES

# CASSETTE 1 SIDE 1

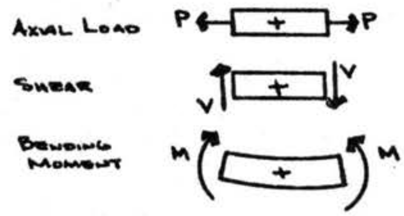
## STRESS RESULTANTS IN BARS

(condition of equilibrium & 2-dimensional space)

**TYPES OF STRESS RESULTANTS**

1. AXIAL FORCE
2. SHEAR OR TRANSVERSE FORCE
3. TORQUE OR TWISTING MOMENT
4. BENDING MOMENT

**SIGN CONVENTION**




## 1. AXIAL FORCE

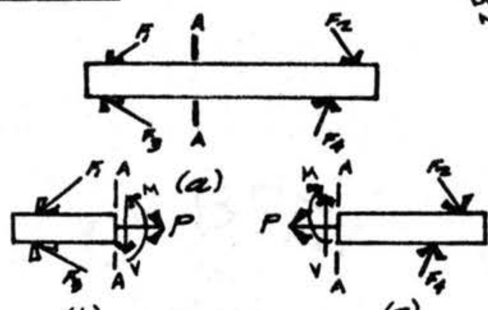
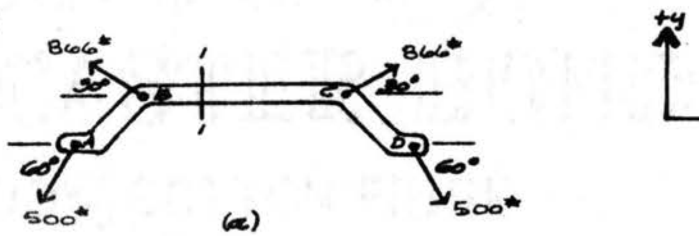



Fig. 1.

EXAMPLE 1.



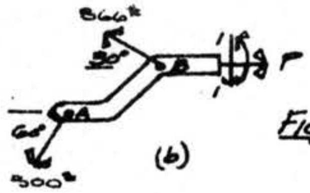




Fig 2.

$\leftarrow \Sigma F_x = 0$

$P - 866 \cos 30° - 500 \cos 60° = 0$

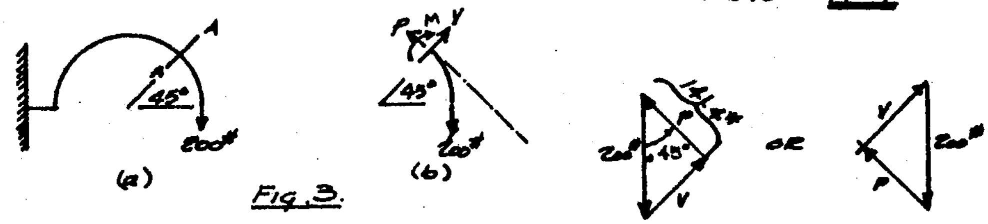
or $P = 866\left(\frac{\sqrt{3}}{2}\right) + 500\left(\frac{1}{2}\right)$

or $P = 750^{\#} + 250^{\#}$

$\boxed{P = 1000^{\#}}$

EXAMPLE 2

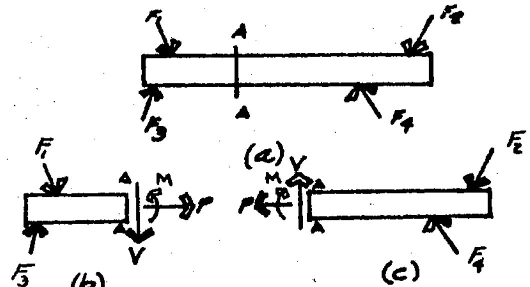
$P = 200 \cos 45^\circ = \underline{141.4}^{\#}$




(a) (b)

Fig. 3.

## 2. SHEAR OR TRANSVERSE FORCE




(b) (c)

Fig. 4

EXAMPLE:

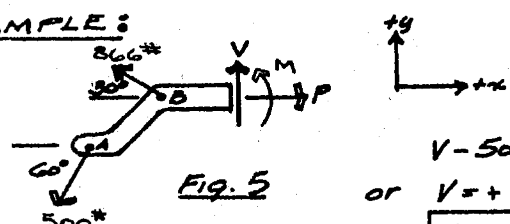



Fig. 5

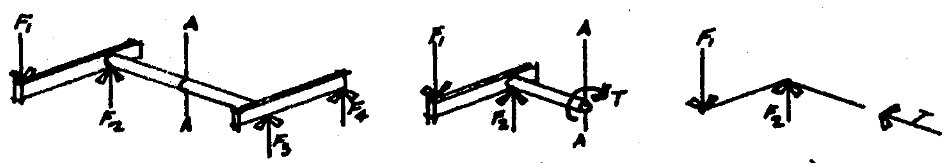
$\Sigma F_y = 0$

$V - 500 \sin 60^\circ + 866 \sin 30^\circ = 0$

or $V = +500(\frac{\sqrt{3}}{2}) - 866(\frac{1}{2}) = +433 - 433$

$\boxed{V = 0\ ^{\#}}$

## 3. TORQUE OR TWISTING MOMENT (moment with respect to axis of bar)




(a) (b) (c)

FIG. 6

NOTE: ON FREEBODY DIAGRAMS (b) & (c) ONLY THE STRESS RESULTANT FOR TORQUE IS SHOWN. WHAT OTHER STRESS RESULTANTS ARE PRESENT?

EXAMPLE:

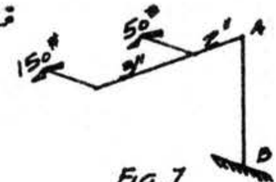
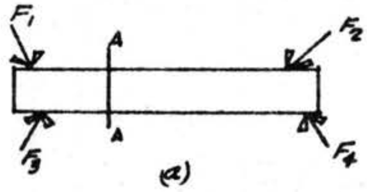



Fig. 7

$T = 150(3+2) + 50(2) = 750 + 100$

$\boxed{T = 850^{\#}\text{-in.}}$

4. BENDING MOMENT (moment with respect to an axis normal to the plane of the bar)



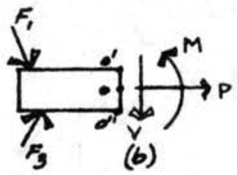
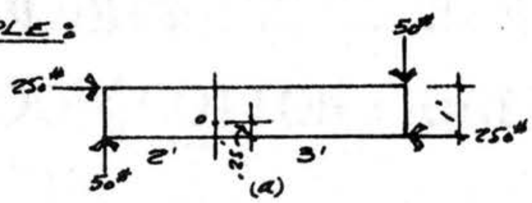




Fig. 8

EXAMPLE:



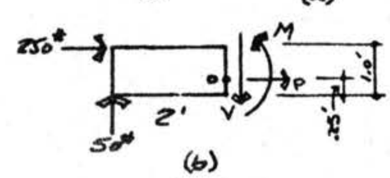




Fig. 9

$M_o = 50(2) + 250(1.0 - .25)$

$= 100 + 187.5$

$\boxed{M = 287.5^{\#}\text{-ft.}}$

## CASSETTE 1 - SIDE 2
## AXIAL STRESS & STRAIN

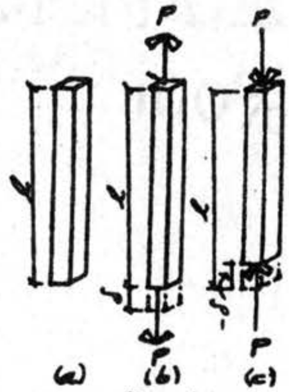



Fig. 1

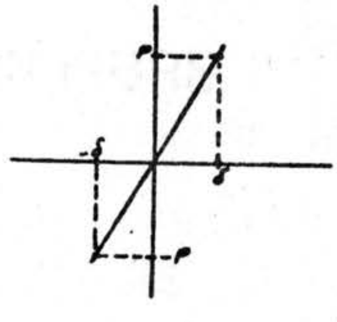



Fig. 2

AXIAL STRESS = $\frac{P}{A}$ = $\frac{\text{total force}}{\text{area over which it acts}}$ = $\sigma$, s, f.

AXIAL STRAIN = $\frac{\delta}{l}$ = $\frac{\text{total elongation (or contraction)}}{\text{total original length}}$ = $\epsilon$, e.

BY EXPERIMENT

$$\delta = \frac{1}{E} \cdot \frac{Pl}{A} = \frac{Pl}{AE}$$ ⟸ HOOKE'S LAW

BUT $\boxed{\sigma = \frac{P}{A}}$ AND $\boxed{\epsilon = \frac{\delta}{l}}$

SO THAT

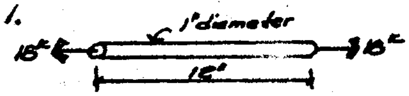
$\sigma = E\epsilon$ OR $\boxed{E = \frac{\sigma}{\epsilon} = \frac{\text{stress}}{\text{strain}}}$

E :≡: MODULUS OF ELASTICITY OR YOUNG'S MODULUS

:≡: "IS DEFINED TO BE"

## EXAMPLE PROBLEMS

1.




k = kip: i.e. kilopound = 1000#

$18^k = 18{,}000^\#$

$\sigma = \frac{P}{A}$

$P = 18^k,\ A = \pi\frac{d^2}{4} = \pi\frac{(1)^2}{4} = 0.785\ in^2$

$\sigma = \frac{P}{A} = \frac{18}{0.785} = \underline{22.9\ ksi} = \underline{22{,}900\ psi}$

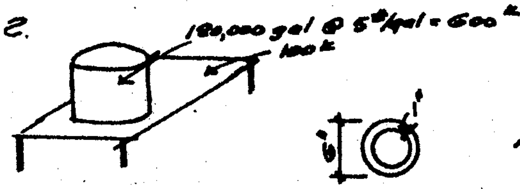
$E_{steel} = 30{,}000{,}000\ psi$

$\epsilon = \frac{\sigma}{E}\ ;\ \delta = \epsilon\ell = \frac{\sigma}{E}\cdot\ell$

$\delta = \frac{22{,}900 \times 12}{30{,}000{,}000} = \underline{9.15 \times 10^{-3}\ in} = \underline{.00915''}$

---

2.




TOTAL LOAD = $600^k + 100^k = 700^k$

LOAD/COL = $175^k$

$A = \frac{\pi}{4}(d_o^2 - d_i^2) = \frac{\pi}{4}(6^2 - 4^2) = 5\pi = 15.7\ in^2$

$\sigma = \frac{175^k}{15.7} = \underline{11{,}100\ psi}$

---

3.

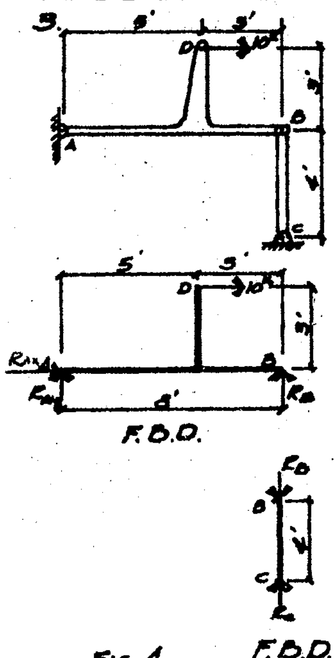



Fig. 4

$\sigma \le 6000\ psi$

$\Sigma M_A = 0 \qquad R_B(8) = 10(3)$

$R_B = \frac{30}{8} = 3.75^k$

$\therefore\ P = 3.75^k$

SINCE $\sigma = \frac{P}{A}$

$A = \frac{P}{\sigma} = \frac{3.75}{6} = .625\ in^2$

$A = \pi\frac{d^2}{4}$

OR

$d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4(.625)}{\pi}} = \sqrt{\underline{0.796\ in}}$

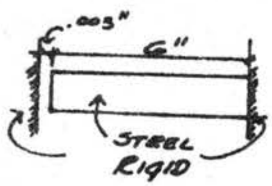
$\underline{d = 0.892\ in.}$

# THERMAL EXPANSION

$$\boxed{\epsilon_t = \alpha \Delta T}$$ $|\text{dim } \alpha| = \text{in/in/°F}$

| MATERIAL | $\alpha$ |
|---|---|
| ALUMINUM ALLOYS | $12.5 \times 10^{-6}$ |
| LOW CARBON STEEL | $6.6 \times 10^{-6}$ |
| STAINLESS STEEL | $9.6 \times 10^{-6}$ |
| MAGNESIUM ALLOYS | $14.5 \times 10^{-6}$ |
| COPPER BASE ALLOYS | $10.0 \times 10^{-6}$ |
| CONCRETE | $6.8 \times 10^{-6}$ |

## EXAMPLE 1:




$T_1 = 60° F$ $\Delta T = 100°$

$T_2 = 160° F$

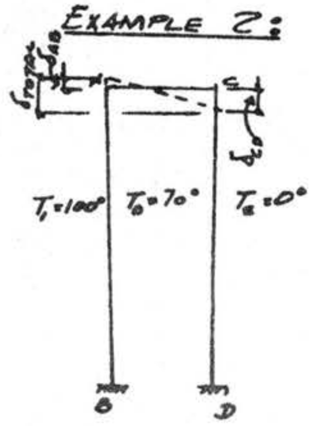
$\epsilon_t = \alpha \Delta T = (6.6 \times 10^{-6})(100) = 6.6 \times 10^{-4}$ in/in.

$\delta = \epsilon_t \ell = (6.6 \times 10^{-4})(6) = 3.96 \times 10^{-3}$ in.

$\frac{\sigma}{E} = \frac{-(3.96 \times 10^{-3}) + (3 \times 10^{-3})}{6} = -.16 \times 10^{-3}$

$\sigma = -(.16 \times 10^{-3})(30 \times 10^{6}) =$ 4800 psi (COMPRESSION)

## EXAMPLE 2:




$\delta_{AB} = \alpha(100-70)(500) = 15000\alpha = 15000(6.6 \times 10^{-6}) = 9.9 \times 10^{-2}$ in.

$\delta_{CD} = \alpha(0-70)(500) = -35000\alpha = -35000(6.6 \times 10^{-6}) = 23.1 \times 10^{-2}$ in.

$\delta_{TOTAL} = 9.9 \times 10^{-2} - (-23.1 \times 10^{-2}) =$ .33 in.

## SUMMARY

AXIAL STRESS

$$\sigma = \frac{P}{A}$$

AXIAL STRAIN

$$\epsilon = \frac{\Delta}{L}$$

HOOKE'S LAW

$$E = \frac{\sigma}{\epsilon}$$

THERMAL STRAIN

$$\epsilon = \alpha \Delta T$$

AXIAL DEFORMATION

$$\delta_p = \frac{PL}{AE}$$

THERMAL DEFORMATION

$$\delta_t = \alpha \Delta T L$$

APPENDIX B

PRINTED TRANSCRIPT

## ENGINEERING SCIENCE 2123

### Lesson I Part I

### MECHANICS OF DEFORMABLE SOLIDS STRESS RESULTANTS IN BARS

Stress resultants in bars. These bars may be either straight or curved. In our considerations we're normally going to limit ourselves to two dimensional spaces, that is, in the X-Y plane. Although, the X & Y axes are not necessarily parallel the edges of your paper.

Likewise, we will restrict ourselves to conditions of equilibrium. That is, summation of forces equal 0 and summation of moments equals 0. You will recall that each of these equations is a vector equation. Quite often we will find it more convenient to resolve these vector equations into three algebraic equations. They may be written summations of forces in the X direction equals 0, summation of forces in the Y direction equals 0, and summation of moments about an axis which is normal to the X-Y plane equals 0.

Now there are four types of stress resultants which we will consider. First, axial forces. These are forces which are parallel to the axis of the bar. Second, shear or transverse forces. These are forces which are normal to the axis of the bar. Thirdly, torque or twisting moment. And fourth, spinning moment. We have indicated a sign convention which we planned to use here and we might as well look at this right now, First, for a positive axial load P this is the sort of force which would tend to cause an elongation or tension or stretching in the bar. Thus, a positive P would be directed to the left on the left hand face or to the right on the right hand face. Positives shear is as indicated, that is upward on the left hand face, downward on the right hand face. And positive bending moment is that which would cause the bar to be concave upward.

Let's look first at the case of axial force. In Figure 1A, I have indicated a straight bar which is acted upon by four external forces, F1, F2, F3, And F4 and let's suppose that the bar is an equilibrium under the action of these forces. And let it be required to find the axial force P at some section indicated AA, We have drawn a free body diagram of the left hand portion of this bar, that is, from the left hand end to the section in question, AA, and this is indicated in Figure 1B. Externally acting upon this bar are the forces F1 and F3. If the bar is to be in equilibrium then there must be internal forces and moments developed at the section AA. The axial force is labeled P, directed to the right (we've indicated it to the right). A shearing force V, which we have shown acting downward and a moment in counterclockwise internally to the bar. These are all unknown for the moment. Equilavently, we could have drawn a free body diagram of the right hand portion of the beam. It is acted upon externally by the forces F2 and F4 in order that this body be in equilibrium and there must be internal forces P and V and an internal moment M. You will note that the magnitude of P for the left hand portion of the bar would be equal and opposite to the force P acting upon the right hand portion of the bar so that if the two pieces of the bar are rejoined, the forces P disappear from view.

Let's look at an example. Look at Figure 2, (2A), in which I have indicated a bar which is composed of some straight segments but is not just a straight little bar and let's suppose that it is acted upon by four forces, A, B, C, and D. At point A there is a 500 pound force acting downward to the left at an angle of 60 degrees, at B, an 866 pound force acting upward to the left at an angle of 30 degrees. At point C, an 866 pound force acting upward to the right at an angle of 30 degrees and at point D, a 500 pound force acting downward to the right at an angle of 60 degrees. And let's suppose that we wish to know what the axial force P is at some section one 1 which is located between B and C. Actually, it can be anywhere between B and C.

In order to calculate P, we will draw then a free body diagram of the left hand portion of this bar. This is indicated in Figure 2B. The 500 pound force acting downward at A and the 866 pound force acting upward at B constitute the two external forces. Internally, there will be the axial force P, a shearing force V, and a moment M. We have indicated by symbol only, the axial force P, since that's what we are asking for at this time. You will also note that I have indicated a little set of axes, X-Y axes, and this time they are parallel to the edges of the paper but they are also parallel and perpendicular to the axis of the bar. And I have indicated what we want to call positive X and positive Y direction. Now in order for this bar to be in equilibrium, then the summation forces internally and externally must be 0. And in particular, summation forces in the X direction must be 0. Using our positive X direction then, we can write P minus the X component of the 866 pound force, 866 cosine 30, minus the X component of the 500 pound force, 500 cosine 60 must be 0. Or transposing and substituting in the trigonometric values, we have P is equal to 866 times the square root of 3 divided by 2 plus 500 times 1/2 or P is equal to 750 pounds plus 250 pounds or P=1000 pounds in the sense indicated, that is to the right. Now had we chosen the right hand portion of the beam to draw for our free body diagram we would have found P again to be equal to 1000 pounds but of course, directed to the left.

Of course, not all bars are straight so let's look at example two, where we have indicated a bar which has a semicircular portion to it. I don't know what this might be, maybe it is a bracket for a wall lamp or a 21st century gallows, suit yourself, but at the free end of this bar there is hanging a 200 pound load and let it be required to find the axial load P at section AA inclined at an angle of 45 degrees to the horizonal. In this case, we can draw a free body diagram of the right hand portion of the bar, that is the portion between the section AA and the 200 pound load.

This is indicated in Figure 3B. There will be two internal forces and one internal moment at the section AA. Now, to calculate, of course, what the value of the axial force P is, we need find only the component of the 200 pound force which lies along the line of action of P. So in this case, we can simply write, P is equal to 200 times the cosine of 45 degrees or 141.4 pounds.

In current mechanics courses, sometimes I think we become overwhelmed with mathematics without realizing that sometimes there are simpler ways of solving problems. In this instance, we know that a single vector equation is the equivalent of two algebraic equations and we know that if we add, that if we have a condition of equilibrium, that is if the summation of forces, these are vector forces now, if the summation of forces equal 0 then the polygon, in this case, a triangle, will close with the vector arrows joining heads to tails. So let's go through this same problem, of course, in an equivalent manner. We can solve a single vector equation for two unknowns. So let's see, we know the 200 pound force in magnitude and direction. We know the direction of the axial force P and we know the direction of the shearing force V; therefore, we know that this can be solved. So let's do it graphically. Choosing some convenient scale, draw the 200 pound force. At an angle of 45 degrees from the head of the 200 pound force, let's draw a line representing the direction of V and from the tail of the 200 pound force, let's draw a line representing the direction of P. Thus, if our drafting ability is reasonably good, we can immediately measure that P is 141.4 pounds directed upward to the left. And of course, I didn't label it, but it is also apparent to you in this case, I think,that the magnitude of V is 141.4 pounds directed upward to the right.

The second kind of force which we consider is shear or transverse force. And in figure 4A I have duplicated the first figure that we had. A straight bar acted upon externally by four forces, F1, F2, F3, and F4, and we wish to find the shearing force at some arbitrary section AA. In order to do this, we can draw a free body diagram of the left hand portion of the beam as shown in Figure 4B. Externally, it is acted upon by the forces F1 and F3. Internally, for equilibrium, there will be an axial force P, a shearing V, and a moment M. Equivalently, we could have drawn the right hand portion of the beam as shown in Figure 4C. It's acted upon by forces F2 and F4 externally; internally, there will be two forces P and V and the moment M. And again, if we were to glue this bar back together, although the forces and moment are present within it, nevertheless, the bar would simply be in equilibrium under the external forces and we would proceed as before.

So let's look at an example. Let's use the same example as we had before as a matter of fact, as shown in Figure 5 where it is required to find the shearing force V at our section One 1, I think it was. We draw the left hand portion of the beam. Externally it is acted upon by a 500 pound force acting downward to the left at an angle of 60 degrees. An 866 pound force acting upward to the right at an angle of 30 degrees, internally then, there must be an axial force P, a shearing V, and a moment M.

Now, I want you to notice something here, that this V which I have drawn would actually represent a negative shearing force according to our convention, although it acts in our positive Y direction. Now in order for this bar to be in equilibrium in the Y direction which happens to be our shear, or transverse, or V direction, we must have summation forces in the Y direction equal 0. And again, using our positive convention here, we have V minus the vertical component of the 500 pound force. That is, 500 times 60 plus 866 times 30 equals 0, transposing and substituting in the trigonometric values, we have V as equal to 500 times the square root of 3 divided by 2 minus 866 times 1/2 or 433 pounds minus 433 pounds or in this instance there is no shearing force.

Our next type of stress resultants which we wish to consider is called torque or twisting moment. That is, a moment with respect to the axis of a bar. If you will refer to Figure 6A, I have indicated a bar, a round bar, which has two rectangular bars, one at either end. And let's suppose that the forces F1 and F2 constitute a couple and the forces F3 and F4 constitute a couple, although someone is going to say that an arrowhead is on the wrong end. Let's don't worry about that right now. And let it be required to find the torque or twisting moment at some section AA between the points of application of forces F2 and F3. In order to determine this torque, let's draw a free body diagram of that portion of the assembly furthest away from you. Externally, this portion is acted upon by the couple caused by forces F1 and F2. Internally then, there must be a resisting torque. Now, at the section AA, there are other forces which I have not drawn. There will again probably be a shearing force and there will probably be an axial force but that's not what we are concerned with right at the moment. The magnitude of P then, must be equal to and opposite the couple caused by the forces F1 and F2, that is their magnitude times the moment arm. From your knowledge of vector analysis, you might wish to represent the torque P as a vector which lies along the axes of the round bar.

Let's go thru an example now. Suppose that we have a bar in an L shape which is attached to a foundation in some manner at point V and let's suppose that the horizonal portion of this bar is acted upon by two forces. One, at a distance of five inches from point A, the magnitude of this force being 150 pounds. A 50 pound force acting at a distance two inches from point A. And let it be required to find the torque then, at any point in the bar between A and B. This is very simply done by stating that the torque then, would be equal to and opposite, therefore, we can write this as an equality rather than as summation equals zero. P is equal to 150 times its moment arm that is 3 plus 2 inches plus 50 pounds times its moment arm of 2 inches or 750 plus 100 or 850 pound-inches.

Now, let me point out to you that in ordinary engineering usage, we would ordinarily talk about pound-inches or pound-feet or often foot-pound or inch-pound.

Lastly, let's consider bending moment. That is, the moment with respect to an axis normal to the plane of the bar and this is extremely important in the study of structural elements. Refer to Figure 8A where we have indicated our old friend again acted upon externally by forces F1, 2, 3, and 4. And let it be required to find the bending moment at some arbitrary but specified point in section AA.

I have drawn a free body diagram of the left hand portion only. Again, we could as well have done it to the right hand portion. This portion is acted upon externally by forces F1 and F3. Internally there will be an axial force P, a shearing force V, and a resisting moment, that is, the bending moment M. It must be equal to and opposite the moment caused by forces F1 and F3. And let me point out to you that I've labeled some points here 00 Prime and 0 Double Prime. That the moment in general, will be different at each of these points. We will see this in an example which I will work very shortly. However, I might also point out that in most of the problems that we're concerned with in this course, if we're dealing with a beam problem, we assume that it has, that it is a line drawing, that it has no thickness up and down and so we simply find a moment at a cross section.

Ok. Let's look at an example. Shown in Figure 9A in which there is a bar which is 5 feet long. It's acted upon by horizonal forces of 250 pounds at the upper edge of the bar on the left; at the lower corner on the right and by vertical forces, 50 pounds acting at the lower left hand corner upward, at the upper right hand corner downward. Now you might verify that the bar actually is in equalibrium. And let it be required to find the moment then, at a point zero which is 2 feet to the right of the left end and a quarter of a foot above the lower edge. In order to determine this moment then, we draw a free body diagram of the left hand portion. Externally, it is acted upon by the 250 pound force horizonal to the right at the upper left corner; the 50 pound force acting upward at the lower left hand corner. Then to find the moment at 0 we take the moment of the external forces. That is, 50 pounds times its moment arm of two feet plus 250 pounds times its moment arm. Now its moment arm you notice that the depth of this bar is on foot so the moment arm will be one foot less .0025 of a foot or .0075 of a foot. And thus, the moment will be equal to 100 plus 187.5 or 287.5 pound-feet.

Lesson I, Part II

## AXIAL STRESS AND STRAIN

In this sketch, I've indicated a straight bar having a length (L) and having some constant cross sectional area A. I've not indicated what the size of A is. I've drawn this bar as having a rectangular cross section but this is not necessary for what follows. Now, let's suppose that along the axis of this bar that we exert two equal and opposite collinear forces and let's suppose that these are tensile forces. Let's call them T. This is indicated in Figure 1B. It is not difficult for you to imagine that these forces cause the bar to stretch and I've indicated the amount of stretch with a small Greek delta. On the other hand, if the direction of these forces were reversed, that is, they became compressive forces, then the length of the bar would be shortened by the same amount. I've labeled this Minus Delta. Now, if you look just to the right of Figure 1 and Figure 2, you will see that we can plot the force T versus the elongation, delta, or the compressive force minus P versus the amount of compression, minus delta. You'll note that I have joined these two points with a straight line. I've done this because we're considering lineally elastic materials.

Let's see now if we can form some definitions. First, axial stress. This is the sign to be P divided by A. That is, the total force exerted over the cross section divided by the area over which it acts. For brevity, we'll designate axial stress as sigma. That's the small Greek Sigma. Some authors use the symbol small f and occasionally the symbol small s. However, in this course, we're going to use small sigma. Axial strain we define, as the total change in length delta divided by the total length L. Total elongation, or total contraction divided by total length. Our symbol for axial strain will be epsilon. Small greek epsilon. Some authors would use the symbol small e. Now, let's look at what the dimensions of these quantities are. In general, in engineering practice, we measure total force in pound and total cross-sectional areas in square inches. So that the usual units for stress will be pounds per square inch. On the other hand, axial strain is defined as a length divided by a length. Therefore, the dimensions of axial strain will be inches per inch. Now, at this point, I think it is well to thoroughly understand the difference between stress and strain. In ordinary conversation, the two words are used as synonyms. Thus, if you're harassed, you might say that you're under stress or under strain and the listener will understand either. This is not the situation however, in deformable mechanics.

By experiment, it may be determined, and has been many times, that the elongation delta is equal to some constant which I have written as one over capital E times the load times the total length divided by the area which we might write as PL divided by AE. Now, you'll remember that we previously defined P over A to be sigma and epsilon is equal to delta divided by L. Therefore, we could write that sigma is equal to capital E divided by epsilon or Capital E is equal to sigma divided by epsilon. This capital E is the one that we talked about on previous tapes. It's called "The

Modulus of Elasticity or Youngs Modulus".

Now just for convenience in our note taking later on, let me define a symbol that I have used and I don't think it will be familiar to you. It's two dots, kind of like a colon, and a little s leaning horizonally followed by two more dots. This is a symbol from mathematical logic and it has the following meaning. That symbol means, "is defined to be." It has a stronger meaning than the symbol for equality.

Suppose we take some time out now from definitions and equations and see if we can get some grasp on what the real life situation is here. With most of the materials that we use in structural design, the kinds of loads, the kinds of axial loads that you're capable of applying at home would result in deformation which would be too small to be measured. However, just to get a, short of a descriptive idea of the thing, let's use a material which I have previously told you was not lineally elastic.

Let's use a rubber band. Now, rubber is elastic but it is not lineally elastic. However, I think it serves pretty well to describe what's going on here. I've given you a little sketch in section three, in Figure 3, again using your take home lab, let's set it up as follows. On the back of the lab kit, insert a bolt as you did on a previous tape, insert it in the center and beneath the bolt tape on a piece of ruled paper. Now over this bolt, hang a rubber band and at the lower end of the rubber band hang a little paper clip. Again you've bent into a shape of a Figure S. On the engineering paper now, note the length of the rubber band where its lower edge is when it is in an unstretched position. Now, on the paper clip hang a washer. Note the elongation of the rubber band. Now hang two washers and three and four until you have stretched the rubber band about as far as you can and noting the change in length each time. When you have completed this, if you will plot a little graph down in the corner of the paper showing total load versus elongation. Don't worry if a line joining the points will be curved because actually a rubber is elastic pretty muchly according to a cubic relationship.

If you have been very observant while you performed this experiment, you would have noticed that as you applied the load to the rubber band that the thickness of the band seemed to decrease. That is, as it got longer it also got thinner. And this isn't too difficult to understand. There are simply so many molocules in the rubber band and they have to fill up so much space and as the rubber band gets longer then it gets thinner. There is however, a very definite relationship between the elongation and the contraction in a normal direction to the elongation. And the relationship between the two factors is called Poisson's ratio. This is ordinarily designated by small greek nu. That's sort of a happy v.

There is another way that you can understand this phenomena. Take four coins of the same diameter, if you're going to the university on a budget use four pennies or if you're affluent, use half dollars. Or if you're real smart, use four of the washers in your kit. And arrange them in a manner that I've indicated in a sketch. Now apply a compressive load as indicated and you will see that the two of these washers will move together while the other two move apart. This indicates this relationship. Now it would be very nice to have this experiment coincide with the one that we've just performed. That is, to apply tensile loads and watch the two of them move apart, watch the two horizonal ones move together. There is a way that you can do this but it is a little bit of trouble. I haven't done it and I would be very happy to see some of you try it. If you were to attach the two opposite washers together with rubber bands or with something that will stretch. In this case, you will have to cut the rubber band and thread it through the washer then tie it back. Then I think it would be possible to apply both tensile or compressive load to opposite washers and see the behavior of the other two washers. This is a graphic and highly exaggerated description of Poisson's ratio.

Let's now apply these principles to some example problems and the first one we will make pretty simple. Let us suppose that we have a one inch diameter steel bar which is twelve inches long and which is actually loaded with a tensile force of 18,000 pounds. Now you notice that I have written that as 18 K. K is simply an abbreviation for Kip which in turn is an abbreviation for Kilo pound. Which is simply 1000 pounds. This is simply a convenience in writing. We will continue to do it throughout the semester. It keeps from writing quite so many zeros. And in this case, of course, 18 K is simply 18,000 pounds. You will recall that our equation relating load, area, and stress is sigma equals P over A. In this case, we know P, that's 18 kips, so in order to calculate the unit stress within the bar, it is necessary first, to find out what its cross-sectional area is. The area of a circle may be given by Pi D squared over 4 or in this case, Pi times 1 squared or 1 divided by 4 which is .785 square inches. Then the axial stress will be P over A or 18,000 divided by .785 or 22,900 pounds per square inch.

Let it also be required to find the total elongation in the bar. In order to do this, it is necessary that we know the modulus of elasticity of the steel. Although, in actuality, this modulus of elasticity is an approximately 29 million pounds per square inch. Frequently in engineering, we simply use 30 million PSI for steel. Then, the relationship or strain equals stress divided by the modulus of elasticity and total elongation delta is equal to the strain times the length which is equal to then, sigma divided by E times L. Thus, the total elongation is equal to 22,900 times the length 12, divided by the modulus of elasticity 30 million which should be 9.15 times 10 to the minus of 3 inches. That is, about .009 of an inch.

As a second example, let's look at some sort of a liquid container which might be needed by say a petroleum refinery, and let's suppose that this container has a capacity of 120,000 gallons. The material which is to be stored in the container is liquid, let's say weighs five pounds per gallon. And let's suppose that the tank and the base upon which it rests weighs

100 kips. The base is supported by 4 pipe columns. Each pipe column is 6 inches in outside diameter and has a wall thickness of 1 inch. Let us find now, what the axial stress is in each pipe column. 120 thousand gallons at five pounds per gallon would be 600,000 pounds or 600 kips. The weight of the tank and platform is 100 kips. Therefore, the total load on the four columns is 700 kips and the load per column is 175 kips. The cross-sectional area of each pipe column is pi over 4 times the outside diameter squared times the inside diameter squared. Or Pi over 4 times 6 squared (36) minus 4 squared or 4, which is 5 Pi or 15.7 square inches. We can then immediately calculate the axial stress as 157 15.7 or 11.1 kips per square inch which of course is 11,100 pounds per square inch.

Now as a final example, let's look at the drawing given in Figure 4. This body is in steady equilibrium and let it be required to calculate the diameter of the member BC under the action of the 10 kip load, if the maximum allowable stress in BC is 6,000 pounds per square inch. I have solved the problem in two parts. In order to find the load on member BC, we must find the either the reaction at B or the reaction at C. You will note that since both B and C are pins then no moment can be present at either point and BC is a two-force member. The two forces must be equal, opposite, and collinear and we seek to find one of these. I have cut the assembly apart as you will note in the drawing immediately beneath Figure 4 and in order to find the reaction at the pin at B, on the member AB I have taken moment about A. Since A is a pinned joint then the moment about A must be equal to zero. Therefore, the reaction at B times its moment arm of 8 feet must be equal to the 10 kip load times its moment arm 3 feet. Or the reaction at B is 30 divided by 8 which is 3.75 kips. I have been drawn the member BC if the reaction at B acts upward at B on the arm AB then it must act downward at B on the arm BC. Therefore, the axial load which we are concerned with is 3.75 kips. We could as well have found the reaction by considering the free body of the entire assembly and taking moment about A. You will note that we would likewise have found a 3.75 kip reaction at C. Now, since sigma is equal to P divided by A then to solve for A we have A equals P divided by sigma or 3.75 kips divided by 6 kips per square inch, or .625 square inches. The area of a circle, as we mentioned before, is given by Pi D squared divided by 4 or solving for D; D is equal to the square root of A divided by Pi or substituting in our numerical values, the square root of 4 times .625 divided by Pi which is about .796 inches. It's reasonable to extend our discussion of axial stress and strain to a consideration of thermal stresses or actually thermal strains. We ordinarily call this thermal expansion. It is an experimental fact that materials, most materials, expand when subjected to a rise in temperature and likewise if they contract when subjected to a decrease in temperature. Now, sometimes this phenomenon works to our behalf and sometimes against us. For example, many machine parts depend upon an interference fit in order that they might work together. Temperature gauges and thermostats depend upon this particular phenomenon. It is very fortunate for us that the coefficient of thermal expansion for reinforcing steel and for concrete are almost the same because in this manner the two materials are able to work together as more or less a homogeneous material. At the same time it is possible sometimes that we have to prepare ourselves against thermal expansion. For example, we plan for expansion loops in steam piping. Or in the case of buildings, we place expansion joints in these buildings to take care of differential expansion.

In order to study this particular situation, let's write the equation, epsilon sub t is equal to alpha times delta capital T. In this equation, epsilon sub t represents the strain due to thermal effects. Delta capital T represents the differential temperature in degrees fahrenheit. And alpha is the coefficient of thermal expansion. In our units, the dimension of alpha will be inches per inch per degree fahrenheit. Alpha may be determined experimentally and I have listed a few values, representative values for alpha, on your notes. This is about all of the theory that is necessary in order to qualify situations involving temperature changes and therefore, we may as well look at a typical example involving thermal expansion.

Refer to example one, this is Figure 1 in which we have a steel bar 6 inches long mounted between two unyielding, that is ridged supports. It is mounted as I have indicated on the right hand support. There is a clearance of .003 of an inch between the left hand end of the bar and the left hand support. Let's suppose that the temperature is 60 degrees and we wish to determine the strain in the bar after the temperature has been raised 100 degrees. That is a final temperature of 160 degrees. Alpha for steel is about 6.6 times 10 to the minus 6. This will be in inches per inch per degree fahrenheit. Now, we could immediately write that the strain in the bar is alpha delta T. That is, 6.6 times 10 to the minus 6 times the temperature differential of 100 degrees or 6.6 times 10 to the minus 4. The elongation of the bar, if it were free to elongate without the support at the left, would be epsilon sub t times the length of the bar, that is, 6.6 times 10 to the minus 4 times the length of the bar, 6 inches or 3.96 times 10 to the minus third.

However, the bar is not free to expand this amount. It can expand only .003 of an inch. The remaining deformation would then be equal to .00096 inches. Dividing this quantity by the length of the bar we find that the strain not due to thermal stresses is .16 times 10 to the minus 3 inches. In other words, we could write our old friend, the relationship between stress, strain, and modulus of elasticity as sigma divided by e is equal to .16 times 10 to the minus 3. Or solving for sigma, the sigma is equal to .16 times 10 to the minus 3 times the modulus of elasticity, that is, 30 times 10 to the 6 or 4.8 times 10 cubed. That is to say, 4800 pounds per square inch.

As a second example, let's look at a tall architectural type structure. Now as might be typified by the Saturn Assembly Building at Cape Canaveral. Now, by dimensions bear little resemblance to reality, I think; I've indicated a structure which is 500 feet high and actually this building was not built with the same size columns extending from the base to the roof. But let's suppose that the columns AB and the columns CD are continuous and let's suppose that the joints at A and the joints at C are made rigid. Furthermore, let's suppose that the building was erected in ideal weather when the temperature was 70 degrees and that because of the beautiful Florida sun that when it shines on one side of the building, that side is raised to a temperature of 100 degrees. And with all due apologies to the Florida Chamber of Commerce, I know this is not, in reality, never happens, but let's suppose that the temperature on the opposite side of the building during a winter day might drop to zero degrees. Then looking at the columns AB, the elongation in that column, if it were made of steel, due to the temperature difference of a hundred minus 70 times the height of the column or 30 alpha times 500 which is 15,000 times 6.6 times 10 to the minus 6 or 9.9 times 10 to the minus 2 inches. That is, 0.099 of an inch.

Likewise, looking at the columns CD we have exactly the same relationship except that in this case, delta T is seventy minus 0 or seventy degrees and so that the elongation in this case, a negative elongation, a shortening of the column, for members CD would be 35,000 times 10 times 6.6 times 10 to the minus 6 or 23.1 times 10 to the minus 2 or .231 inches. Thus, the differential elongation between the columns AB and the columns CD would be the algebraic sum of these two quantities. That is 9.9 times 10 to the minus 2 plus 23.1 times 10 to the minus 2 or about a third of an inch, .33 inches. Now this may seem like an insignificant quantity to you but in the design of such a structure, this would be taken into account because without it taken into account, stresses would be developed, particularly in the members AC which could cause either undue deflection or in some cases, could actually cause a member that is a joint to fail. And therefore, the consideration of temperature differences in structures having dimensions comparable to 500 feet or greater in many cases less than 500 feet, these must be taken into account in the design of the structure.

APPENDIX C

POST-TEST I

ENGINEERING SCIENCE 2123
Lesson 1 Test

____________________ NAME          ____________ SECTION

## STRESS RESULTANTS IN BARS

1. For equilibrium conditions: $\Sigma F =$ ______ $\Sigma M =$ ______ ?

2. If the force and moment equations are written as vectors, the moment equation is taken about an axis ____________________ ____________________ to the x-y plane.

3. Shear or transverse forces are ____________________ to the axis of the bar.

4. What are the four types of stress resultants?

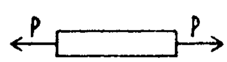
(A) ______________________________

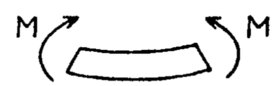
(B) ______________________________

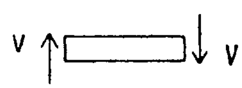
(C) ______________________________

(D) ______________________________

5. Indicate the proper sign convention for diagrams below and label the diagrams appropriately.

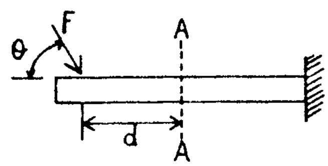
(A) ________ 

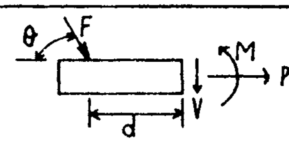

(C) ________ 


(B) ________ 


6. Looking at the free body diagram below, write the equation for the axial force on the cut section.

______________________________




7. For the same free body diagram, write the equation for the shear force on the cut section.

______________________________

8. Using the free body diagram in question 6, find the moment on the section AA.

______________________________

## AXIAL STRESS AND STRAIN

9. What are the common symbols for: (A) Axial Stress ____________

(B) Axial Strain ____________

Lesson I Test

10. What are the dimensions of: (A) Stress ____________________

(B) Strain ____________________

11. What is stress divided by strain? ____________________

12. Hooke's law applies to what type of material? ____________________

13. What is the effect on axial deformation if the area of the bar is doubled while the stress remains unchanged?

____________________

14. What is the effect on axial deformation if the length of the bar is doubled while the stress remains unchanged?

____________________

15. Suppose you had a cylindrical bar (i.e.) a rod) and applied some axial force P. Now suppose you secure another rod of the same material, twice as long with a diameter twice as great. What would be the relationship of the deformations in the two rods if you applied twice the force to the larger rod?

____________________

16. The absolute value of the ratio between the elongation of a bar under tension and the contraction of the bar in a direction normal to the elongation is called .

____________________

17. What is the equation for thermal expansion?

APPENDIX D

POST POST-TEST

TEST 4
ENG SC 2123

NAME____________________ SECTION__________

1. $\tau_{xy}$ acts on a plane which is ____________________ to the x axis.

2. List the four types of stress resultants?

(A) ________________________________________

(B) ________________________________________

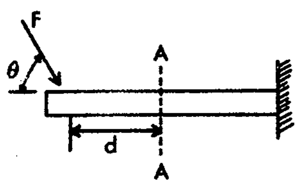
(C) ________________________________________

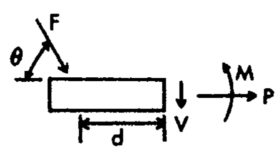
(D) ________________________________________

3. The maximum normal stress in a solid is called____________________.

4. For problems of direct shear, we assume the shearing stress to be distributed ___________________________ over the area subjected to shear.

5. Looking at the free body diagram below, calculate the internal stress resultants and give their signs.




(A) P________________

(B) V________________

(C) M________________

6. The plane of maximum shearing stress differs from the plane of maximum normal stress by what angle?____________________________

____________________________________________________________.

7. To find the shearing stress on a plane subjected to direct shear, we simply divide the shear force by____________________________.

8. The graphical representation of the state of stress at a point by means or orthogonal axes and a circle is called__________________

____________________________________________________________.

9. Shear strain is (a) a change in length, (b) a change in angle, (c) a change in circumference.

10. What are the dimensions of: (A) Stress____________________________

(B) Strain____________________________

11. The center of Mohr's circle is defined by the quantity___________

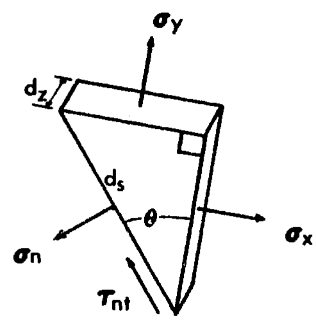
____________________________________________________________.

12. Poisson's ratio for steel is a number (a) greater than one, (b) Less than one, (c) 2.9 x $10^7$ PSI.

13. Hooke's law applies to what type of material?__________________.

14. What is the total normal force on the upper plane of the figure below? ______________________________

15. What is the total force in the plane of the inclined plane defined by ds?______________________________




16. The value relating shearing stress and shearing strain in an elastic material is called ______________________________.

17. If a material exhibits the same properties at every point, it is called ______________________________.

18. What is the effect on axial deformation if the area of the bar is doubled while the stress remains unchanged?

______________________________

19. Area Times stress yields ______________________________.

20. The fundamental principle involved in the derivation of the equations for state of strain at a point is:

(A) Hooke's Law

(B) Equilibrium

(C) Stresses are below proportional limit

(D) Stresses are vectors

21. List three common non-metallic building materials: ______________,

______________________, and ______________________.

22. Suppose you had a cylindrical bar (i.e.) a rod) and applied some axial force P. Now suppose you secure another rod of the same material, twice as long with a diameter twice as great. What would be the relationship of the deformations in the two rods if you applied twice the force to the larger rod?

____________________________________________

23. T F $|\tau_{xy}| = |\tau_{yx}|$

24. If the modulus of elasticity of steel is approximately 30 x $10^6$ psi and the modulus of elasticity of aluminum is 10 x $10^6$ psi, which of two members having the same length and cross-sectional area (one of aluminum and one of steel) would deform the most if they are loaded equally?____________________.

25. The point on the stress-strain curve at which the material ceases to behave elastically is called____________________.

26. The absolute value of the ratio between the elongation of a bar under tension and the contraction of the bar in a direction normal to the elongation is called

__________________________.

27. <u>FOR THE STRESS BLOCK SHOWN BELOW</u>:

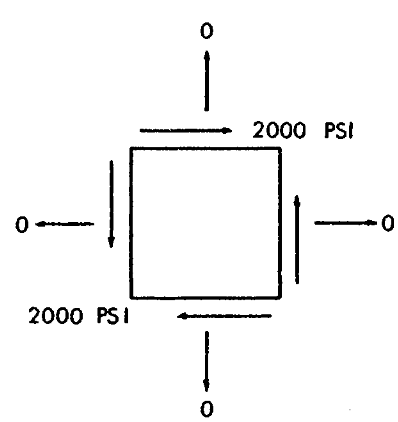
27. What is the maximum shear?____________________________

28. What is the maximum normal stress?________________________

29. What is the minimum normal stress?________________________

30. What is the normal stress when the shear is zero?________________

____________________________________________



31. Underline the term in the following which does not apply to aluminum: (a) ultimate strength, (b) yield point, (c) elastic limit, (d) proportional limit.

32. The initial slope of the stress-strain curve yields the

    ______________________________________.

33. The work done on a material per unit volume is known as its

    __________________________________________.

34. The maximum energy that can be stored elastically in a material or the maximum energy that can be recovered from a material is called______________________________________.

APPENDIX E

ATTITUDE QUESTIONNAIRE

Name_________________________________ Section No.______

OPINION QUESTIONNAIRE ENGR. SCI. 2123

We are concerned with your opinions regarding two Audio-Tutorial methods used this semester in Engineering Science. If this questionnaire is to be of any value, your responses must be honest. This is not a test and you will not be graded. This questionnaire contains several statements to which there are no right or wrong answers. The only answer is your own feelings or your own opinion. Do not respond as you think you should but, instead, according to how you feel personally.

All the questions differ and it is not necessary that you be consistent from question to question. Rather, it is desirable that you answer each question according to how you feel about it, unaffected by previous answers you have given. We can assure you that all the information which you give us will be kept strictly confidential. It will not be graded by your instructor. It will in no way influence your grade.

SA-Strongly Agree; A-Agree; U-Undecided; D-Disagree;
SD-Strongly Disagree

For each of the following statements, circle the letter or letters which most closely represent your idea concerning that statement.

SA A U D SD Had the method of presentation not been assigned, I would have chosen the method assigned to me anyway.

SA A U D SD I would recommend the method of presentation assigned to me to my friends.

SA A U D SD The method of presentation assigned to me was more difficult than the alternate presentation.

SA A U D SD I expect little of the method presentation assigned to me and was not disappointed.

SA A U D SD Even though I am reluctant to admit it, the method of presentation assigned to me was interesting.

SA A U D SD I have seen no advantage in using the method of presentation assigned to me over the alternate method.

SA A U D SD I believe that 60 % of the students using the method of presentation assigned to me disliked the method when compared to the alternate presentation.

SA A U D SD If the method of presentation assigned to me had not been required, no students would have selected it.

SA A U D SD I believe that all students could benefit from using the method of presentation assigned to me.

SA A U D SD Ignoring my own scores, I feel that the two methods of presentation are equal in ease of use.

Thank you very much for your contribution.

VITA [3]

Woodfin Grady Harris, Jr.

Candidate for the Degree of

Doctor of Education

Thesis: A COMPARISON OF STUDENT PERFORMANCE IN A COLLEGE ENGINEERING COURSE BETWEEN TWO LECTURE METHODS: A TAPED RECORDING AND A PRINTED TRANSCRIPTION

Major Field: Higher Education

Biographical:

Personal Data: Born at Little Rock, Arkansas, August 2, 1928, the son of Woodfin G. and Gladys Harris.

Education: Attended Little Rock Public Schools through the eleventh grade, attended Lawton Public Schools for the senior year and graduated May, 1946; attended Cameron State College 1946-1948; received the Bachelor of Science degree from Oklahoma State University, Stillwater, Oklahoma, in May, 1954, with a major in Industrial Arts Education; received the Master of Science degree from Oklahoma State University, Stillwater, Oklahoma, in August, 1954, with a major in Industrial Arts Education; received the Specialist in Education degree from Indiana University, Bloomington, Indiana, in September, 1963, with a major in Audiovisual Communications; completed the requirements for the Doctor of Education degree at Oklahoma State University in July, 1971.

Professional Experience: Teacher, Industrial Arts; i.e., Photography-Printing-Mechanical Drawing, U. S. Grant Jr.-Sr. High School, Oklahoma City, Oklahoma, Fall 1954-Spring 1957; Teacher-Audiovisual Coordinator, U. S. Grant Jr.-Sr. High School, Fall 1957 to Spring 1961; Half-time Graduate Assistant at Indiana University, Bloomington, Indiana, Fall 1961; Spring of 1963 as photographer and lab technician. August, 1963 to December, 1966, Director of Audiovisual for the Oklahoma City Public Schools, Oklahoma City, Oklahoma; January, 1967-January, 1968, Audiovisual Production Specialist, Oklahoma State University, Stillwater, Oklahoma; Associate Director, Audiovisual Center, January, 1968, to June, 1971, Oklahoma State University, Stillwater, Oklahoma; Director, Audiovisual Center, Oklahoma State University, July, 1971.