

THE CONSTRUCTION OF AN ACHIEVEMENT TEST IN PLANE GEOMETRY

by

Maude McMIndes

B. S. in Education,  
State Teachers College,  
Hays, Kansas,

1916

Submitted to the Department of Education and  
the Faculty of the Graduate School of the  
University of Kansas in partial fulfillment  
of the requirements for the degree of Master  
of Science in Education.

Approved by:

*F. P. O'Brien*

Date

Dec, 1926.

*Raymond A. Schwagerl*  
Head of Department

## ACKNOWLEDGEMENTS

It is impossible to express fully the indebtedness of the author to all of the teachers, school administrators, and geometry students who have so cheerfully cooperated in providing the data upon which this study is based.

To Dr. F. P. OBrien, the writer acknowledges a grateful appreciation of his supervision at each stage of the study; to Mrs. F. P. OBrien, an appreciation for her critical analysis of the test elements in the first stages of the preparation of the test; and to Dr. Ben D. Wood, an appreciation for the inspiration to study objective measurements and for suggestion throughout the construction of the test.

## TABLE OF CONTENTS

| Chapter |  | Page |
|---------|--|------|
| I       | THE NATURE AND SCOPE OF THE PROBLEM                            | 1    |
| II      | CONSTRUCTIONS OF EXPERIMENTAL EDITIONS OF TEST                 | 9    |
|         | A--Analysis of data and revision of First Experimental Edition |      |
|         | B--Analysis and test results of Second Experimental Edition    |      |
| III     | SUMMARY AND CONCLUSION   | 35   |
|         | BIBLIOGRAPHY   |      |
|         | APPENDIX   |      |

# THE CONSTRUCTION OF AN ACHIEVEMENT TEST IN PLANE GEOMETRY

## CHAPTER I

### THE NATURE AND SCOPE OF THE PROBLEM

The need for objective measurement in Plane Geometry is apparent to all who are familiar with the unreliability of teachers' marks and other subjective measures commonly used to evaluate the instruction results in that subject.

It was recognition of this situation which led the author to undertake the construction of an objective test in Plane Geometry. A rather intensive inquiry by the writer of the efforts that had been made to provide objective tests in general and in geometry in particular preceded this study.

An analysis of the literature in the field of objective measurement in geometry revealed that one of the first attempts at an economical objective test in geometry was made by William H. Metzler of the Syracuse University in 1912. This was followed by experimental studies in geometry testing by Truman Lee Kelly in 1914, by L. V. Stockard and J. Carlton Bell in 1916, by Dr. Minnick in 1918, by Raleigh Schorling in 1919, by L. L. Thurstone in 1919, by Agnes L. Rogers in 1921, by Vera Sanford and Raleigh Schorling in 1923, and by Herbert E. Hawkes and Ben D. Wood in 1924.

The Minnick, Schorling, Sanford-Schorling, and Hawkes-Wood tests were strictly geometry tests while the other tests

were more general tests in mathematics but contained a section pertaining to geometry testing.

While these geometry tests contain many worthwhile criteria for geometry testing and are valuable contributions, yet they have some outstanding limitations or disadvantages. The Minnick tests scores are regarded by those who have tried to use them as highly subjective. The Schorling test which has been revised into the Sanford-Schorling Achievement Test in Plane Geometry seems rather limited in its content. The Hawkes-Wood Placement Test in Plane Geometry contains the criteria of a good test but has been derived chiefly for the purpose of a placement test in Columbia College.

An inquiry into the technique of test construction was also made by the writer. Particular attention was given to the development of the Hotz Algebra Scales<sup>1</sup> and the Woody Arithmetic Scales<sup>2</sup>. The reports of these studies provided many valuable suggestions for the author in the development of this test in plane geometry.

In preparing this test, the author endeavored to incorporate in it a large number and a wide range of geometric principles, being guided by the recommendations of the National Committee on Mathematical Requirements and by the content

---

1. Contribution to Education No. 90--Teachers College, Columbia University  
2. Contribution to Education No. 89--Teachers College, Columbia University

---

common to six of what are regarded as the leading geometry text-books in use at the present time. The test elements were prepared with precision and care so as to limit to a minimum the mechanics of the solutions required. These test elements were organized into three types of objective measurement, namely, a True-False test, a Logical Selection test, and a Problem test. The three were then combined to form the geometry test. It seemed advisable to develop two forms of the test at the same time and if possible to make the forms equivalent.

The test is intended to measure the achievement of geometry students who have completed the course in plane geometry. This will usually mean that they will have had a year of the subject. The test was not restricted to any particular class in school but to those students who had completed the course in plane geometry. However, ninety per cent of the students participating were sophomores in their high school classification.

The time consumed in the construction of this test in plane geometry extended over a period of two school years. The First Experimental Edition, including Forms A and B, was given at the completion of the course in Plane Geometry in 1925 and the Second or Revised Edition at the completion of the course in 1926. Several schools participated in giving the tests both years but the students participating were of course not the same individuals excepting a few who

were repeaters because of failure and other similar reasons.

In the first Experimental Edition, the two forms of the test were not sent to the same school. Owing to delay in the printing of Form B, Form A was sent out first, as it was near the close of the school year for some of the schools cooperating. Form A was sent to fourteen high schools and Form B to eleven high schools whose enrollment in geometry ranged from fourteen to several hundred students. In order that the territory represented in the testing be as wide as possible and the sampling scattered with reference to the schools, included, two hundred copies of the test was the maximum number sent to any school. Copies of the test were also sent to a few individual students who had ranked high in a state wide contest in geometry.

The territory represented in the First Experimental Edition included schools in California, Colorado, Kansas, Oklahoma, Nebraska, Iowa, and Ohio. About seventy-five per cent of the schools participating in this edition were from Kansas. The reason for this was that replies from the letter inviting their cooperation were received earlier from schools in Kansas than from schools outside the state. Many of the schools were preparing to close for the year and urged that the tests be sent as soon as possible. The writer not anticipating such a generous response from schools outside the state, filled all orders as soon as the request was received. By the time many of the orders from outside the state were received, the test supply had been exhausted.

One thousand copies of each form of the test had been printed and distributed. The analysis of test results is based on approximately 815 geometry students who took Form A of this edition and 845 geometry students who took Form B.

In sending out the revised edition of the test the two forms were sent to the same schools. Each school was instructed to give both forms to the same geometry students. Replies from the letters soliciting the cooperation of schools were received well in advance of the time the tests were needed. So many schools agreed to cooperate, it was soon evident that the supply of tests would not meet the demand although fifteen hundred copies of each form had been printed.

The schools responding to this request ranged from those having an enrollment in geometry of nine to those having several hundred students in geometry. This number included rural high schools, high schools of first, second and third class cities in Kansas and high schools of other states. A few large metropolitan high schools of other states, and two classical high schools in the New England States were also included. The following states were represented in this sampling: Colorado, Kansas, Missouri, Oklahoma, Illinois, Michigan, Minnesota, Ohio, Texas, Tennessee, Pennsylvania, Massachusetts, Oregon and Washington.

The writer desired to secure returns from a varied sampling of schools. Accordingly, both forms of the revised

test were sent to thirty schools. Two schools were late in returning their reports and they were not included in this study. Data from twenty-eight of the thirty schools are used in the analysis of this revised edition. The analysis is based on the test papers of 1085 geometry students on Form A and 1122 on Form B. A few schools did not follow the request that they give both forms to the same students. However, 944 students did take both forms and this number is regarded by the author as sufficient to indicate the reliability of the test.

Norms were later computed, based on the gross scores of each test form. Some of these tests were given to so-called good groups, selected according to the classification of students on the basis of their geometry grades in school, and some to poor groups of students. Most of the classes or students represented in this study were not so classified. Twenty-five per cent of the schools included in this testing program included the entire geometry enrollment. The two schools with the highest median scores were schools whose entire enrollment in geometry was tested.

To enlist the cooperation of teachers and principals in this testing program, letters were sent to superintendents, principals, and geometry teachers. In the letter sent for the purpose of enlisting participation in the first experimental edition, the writer set forth the need of standardized objective measurement in geometry achievement and the need of their

help in this undertaking. With reference to the second edition, the writer asked for their cooperation for the purpose of perfecting the tentative scale, of providing norms, and of indicating the reliability of the test.

The writer feels that much credit for the fine response received from the schools was due to another letter which was written by Dr. F. P. O'Brien, a copy of which was sent to each school, urging that the undertaking merited their cooperation. A post card was also enclosed for the convenience of school officials or teachers in replying. Blanks on the cards were provided for the following information: Name, address, desire to cooperate, number of test copies wanted, and date tests were wanted.

The response from the cooperating schools was beyond expectations. Many requests were accompanied by such remarks as "Glad to cooperate" etc. A few replies were not so complimentary, as "Test too Long." In the letter soliciting cooperation, the writer asked for criticism from both teachers and pupils. The replies contained both constructive and destructive criticism. Many teachers cooperating in the first edition, expressed a willingness to cooperate also in giving the second edition of the test. All were anxious to have a report on the relative ranking of their students in the test. On each edition, replies were received from about seventy per cent of the letters sent out.

It is the aim of this study to derive two equivalent

forms of an objective test for measuring the achievement of students who have completed a course in plane geometry. The following chapter will present an analysis of the test scores in both forms of the first experimental edition of the test and of the revised edition of the test. The relative difficulty of each element included in the various divisions of the test and the selection of the elements included in the revised edition of the test will be presented. Likewise, scattergrams will indicate the relationship between scores on the two forms of test by the same students.

## CHAPTER II

## CONSTRUCTION OF EXPERIMENTAL EDITIONS OF TEST

## A--Analysis of data and revision of First Experimental Edition

The content of this geometry test was based on the analysis of six geometry text-books. No test element was included unless the principle involved was contained in all of the texts and the terminology was common. The recommendations of the National Mathematical Association Committee on the Reorganization of Mathematics in Secondary Schools were carefully studied. The writer had also profited by several years of experiences in writing objective geometry tests for class room use.

In the construction of the First Experimental Edition of the test, approximately twenty-five per cent more test elements were used than the author expected to use in the revised form. This provision was to allow for some probably necessary elimination in the revised form of the test.

The content was equalized in the two experimental forms on the basis of the writer's judgment and experience, the chief aim being to duplicate in the second form problems involving the same geometric principles as were found in the first form. Each form of the experimental tests consisted of four divisions representing four types of objective tests, namely, True-False, Problems, Multiple Choice and Constructions without Proof. The time allowed and the number of test elements of each type were as follows:

| Type of Test                | Time allowed | Number of Test Elements |
|-----------------------------|--------------|-------------------------|
| True-False Problems         | 30 min.      | 90                      |
| Multiple Choice             | 30 "         | 45                      |
| Constructions without Proof | 30 "         | 42                      |
|                             | 10 "         | 5                       |

The items were roughly arranged in the order of difficulty as based upon the test results secured from giving the test to sixty geometry students of an unselected group.

Identification data provided with each test paper consisted of name, grade, age, sex, date, school, city, number of months geometry had been studied, and name of geometry text book studied. It took very little time to get this information and the writer thought it might be of valuable assistance in some unforeseen difficulty that might arise. It might also provide data for other new studies such as a comparison of the achievement of boys and girls in the same geometry course or a study of age norms in the test. Since the schools were asked to give the test as near the completion of a course in plane geometry as it could be given, the range of variation in the number of months the subject was studied was expected to be small. The returns from the experimental edition verified this assumption. The range was from eight and one-half months to nine and one-half months. About eighty-five per cent had studied geometry eight and one-half months.

General Directions and Special Instructions to Examiners<sup>1</sup>

<sup>1</sup> See copy of test and directions for giving it--Appendix p-1

were provided with test and they were made as explicit as the writer was able to make them.

A typewritten copy of the test in its tentative form was sent to the following for their criticism: One individual who has made an extensive study of objective tests and also an author of several tests, two other individuals who have carried on extensive studies involving the use of objective tests, one individual who is actively engaged in educational work but had little experience with objective tests, a committee of Mathematics Teachers in a large high school, local geometry teachers, former geometry students, and several students who were about to complete the course in Plane Geometry. The first four mentioned made a critical study of the test and two of them and a former geometry student analyzed practically every test element and commented specifically while the others commented in more general terms.

A noticeable feature consisted in the fact that the former geometry student, who made a study of each test element, made comments parallel to those made by persons who had had considerable experience with tests. Guided by the suggestions received from these persons, corrections were made in some elements and the test was sent to the printer. One thousand copies of each form were printed.

The schools and the geometry classes from which test results were received varied considerably in size. The range in the number of students reporting per school and the total number of geometry students reporting on each type of test is shown in the

following summary:

| Type of Test    | Form A |           | Form B |          |
|-----------------|--------|-----------|--------|----------|
|                 | Range  | Total No. | Range  | Total No |
| True-False      | 12-142 | 823       | 19-178 | 851      |
| Problems        | 11-142 | 818       | 18-176 | 848      |
| Multiple Choice | 12-135 | 795       | 18-174 | 825      |

The scoring of the fourth division of the test, "Constructions without Proof," was found to be too subjective for further use in this test so it was not completed and was not included in the revised edition of the test.

A scoring key was devised for scoring each of the three divisions of the test in each form.

The writer did all the scoring of the tests in this edition in order to become more familiar with the type of responses received. This experience served also as a kind of critical study of the individual test elements with reference to ambiguity, scorability or other similar features which deserved special attention. Each element of the test was scored right, wrong or omitted. The wrong elements were checked thus ✓; the right were unchecked; and the omitted ones were unchecked. They were easily designated from the right ones since the omissions were evident. All scores are stated in terms of the number right. The scores in the three subdivisions of each form of the test were analyzed as separate units of the test.

In making this analysis, each test element was listed separately and opposite it was listed the total number of correct

responses. A sample of the procedure follows:

---

Table I (a) A list of test elements and the number of correct responses each received. True-False Section, Form A, Geometry Test.

---

| No. of the test elements | Total number of correct responses |
|--------------------------|-----------------------------------|
| 1                        | 801                               |
| 2                        | 536                               |
| 3                        | 394                               |
| 4                        | 311                               |
| 5                        | 535                               |

---

A complete table for each of the three divisions of each Form will be found in the Appendix--Table I (a) to (f)

The next step was the ranking of the test elements in the order of their difficulty from easier to more difficulty according to the number of correct responses that each received. Number one is the element receiving the greatest number of correct responses and therefore regarded as easiest for the students tested. All elements were ranked in this manner. A sample of this step in the procedure follows:

---

Table II (a) Rank of test elements in order of difficulty according to number of correct responses received. True-False Section-Form A of Geometry Test.

---

| Rank Assigned | No. of Correct Responses | No. of test element involved. |
|---------------|--------------------------|-------------------------------|
| 1             | 801                      | 1                             |
| 2             | 778                      | 8                             |
| 3             | 772                      | 44                            |
| 4             | 749                      | 37                            |
| 5             | 729                      | 38                            |

Complete tables for each of the three divisions of the test will be found in the Appendix--Table II (a) to (f)

The corresponding divisions of the two forms were then thrown into one difficulty ranking. The test element receiving the greatest number of correct responses was ranked number one and the process continued until all elements of that division were ranked. On each division of the test, the number of students tested on the two forms was near enough the same number to justify this.

Perhaps a word of explanation regarding the procedure illustrated in Table III, which follows, will be appropriate here. The table served three purposes in the analysis. Column one indicates the total of correct scores on the elements in Forms A and B when they were thrown into one difficulty ranking; columns two and three locate the elements with reference to the original tests; column four shows which elements were selected or omitted from the revised edition of the test.

---

Table III (a) Sample of how the analysis of test results was made in the construction of Forms A and B of the Revised Edition (True-False Section of Geometry Test.)

---

| No. of correct responses | Original Form Represented | No. of test element in original form | Elements later omitted or as classed in Revised Forms |
|--------------------------|---------------------------|--------------------------------------|---|
| 801                      | A                         | 1                                    | omit  |
| 791                      | B                         | 1                                    | omit  |
| 778                      | A                         | 8                                    | omit  |
| 772                      | A                         | 44                                   | A   |
| 749                      | A                         | 37                                   | B   |
| 742                      | B                         | 3                                    | B   |
| 729                      | B                         | 6                                    | A   |

---

Complete tables for each of the three divisions of both forms will be found in the Appendix-Table III (a), (b), (c).

Further analysis was made by comparing the success of the one hundred best students on each element with the success of the one hundred poorest students on the same element. The best students were those whose total scores ranked highest and the poorest students were those whose total scores ranked lowest. The one hundred best students will be termed "Good Group" in this study and the one hundred poorest students will be termed the "Poor Group." The procedure was as follows:

---

Table IV Success of the Good Group and the Poor Group on the same test element of the True-False Division of the Geometry Test.

---

| Number of Test Element | Scores by Good Group | Scores by Poor Group |
|------------------------|----------------------|----------------------|
| 1                      | 100                  | 100                  |
| 7                      | 22                   | 24                   |
| 8                      | 99                   | 93                   |
| 38                     | 96                   | 90                   |
| 60                     | 68                   | 4                    |

---

Elements No. 1, 7, 8 and 38 were regarded as "no good" for test purposes because they did not differentiate between good and poor students. They did not separate "the sheep from the goats." In contrast to these elements, number 60 appears satisfactory as a measure of geometry achievement. Complete tables for each division of each test may be found in the Appendix Table IV (a) to (f).

After the elimination of unsatisfactory test elements, revised forms of both tests were constructed in the manner already stated. For complete tables of the three types of each form, see Appendix--Table III (a), (b), (c).

No attempt was made to have the test elements come at exactly equal intervals on the scale with reference to difficulty. The chief aim was to get two equivalent forms with reference to the elements involved. In other words, the elements were paired, with one of the pair in each form

of the test. After the new forms had been tentatively constructed, a statement was prepared of the total number of correct responses made by students on each of the elements. This was based on the number of correct responses each element had received in the original form of the test. A sample of the procedure follows:

Table V (a) Total number of correct responses for each of the test elements of the revised test (True-False Division)

| No. of test element | Form A<br>Correct Responses | No. of test element | Form B<br>Correct Responses |
|---------------------|-----------------------------|---------------------|-----------------------------|
| 1                   | 772                         | 1                   | 749                         |
| 2                   | 742                         | 2                   | 743                         |
| 3                   | 745                         | 3                   | 691                         |
| 4                   | 664                         | 4                   | 678                         |
| 5                   | 656                         | 5                   | 652                         |

For complete tables of the three divisions of each form, see Table V (a), (b), (c).

A summary of the total aggregate number of correct responses on elements in each division of the two forms of the test as revised is presented here.

| Division of Test    | No. of elements in Test | Total No. of correct responses Form A | Total No. of correct responses Form B |
|---------------------|-------------------------|---------------------------------------|---------------------------------------|
| True-False Problems | 90                      | 27297                                 | 27716                                 |
| Multiple Choice     | 45                      | 7001                                  | 7008                                  |
|                     | 42                      | 10750                                 | 10361                                 |
|                     | Total                   | 45048                                 | 45085                                 |

The two forms were therefore considered to be equivalent with reference to the number of student responses employed.

A table of the newly constructed test elements was prepared indicating the new number and form of each test element and its corresponding original number and form. These tables may be found in the Appendix--Table VI (a), (b), (c).

The Revised Edition termed the Second Experimental Edition was printed in time for distribution at the close of the 1925-26 school year.

## B-ANALYSIS AND TEST RESULTS ON SECOND EXPERIMENTAL EDITION

In the Second Experimental Edition each of the two forms was considered as a unit, rather than the subdivisions of each form, as was done in the first edition.

The time limit for each form of the test was fixed at sixty minutes as that seemed to be adequate for most students and the time that best fitted class schedules of the schools. Teachers and administrators also expressed approval of this time allowance. The sixty minutes were divided into 20, 10 and 30 minute periods for the three divisions of the test.

The time allowance of the experimental edition was ninety minutes. Both the number of test elements and the time period were reduced in the revised edition. The distribution of time allowed to each division of the revised test and the number of test elements in each are indicated here.

---

| Type of Test<br>subdivision | Time    | No. of Test Element |
|-----------------------------|---------|---------------------|
| True-False                  | 20 min. | 75                  |
| Logical Selections          | 10 min. | 30                  |
| Problems                    | 30 min. | 30                  |

---

It may be noted that the order of the last two divisions of the test was interchanged from that in the first edition, since the combined time allowed the True-False and Logical Selection Divisions equals the time allowed the Problem division. The change seemed more likely to meet the approval of these teachers and administrators whose class schedules are based on 40 minute periods. The term Multiple Choice for one division

of the test was changed to Logical Selection to conform more nearly to the current usage of the terms.

Some few changes were made in the General Directions and Special Instructions to Examiners<sup>1</sup> to conform with the general changes in the revised test. The Identification data, requested from each student remained practically unchanged from what the first edition included.

In addition to asking the schools to give the two forms of the test to the same pupils, some schools were asked to give Form A first and others to give Form B first in order that practice effects on either form would tend to be neutralized. The equalization of numbers in this division of schools was determined before the tests were sent out so that half the students took the forms of the test in the A, B order, and half in the B, A order.

The test was administered by the geometry teachers whose students took the test.

The writer graded all of the Problem division and about thirty per cent of the True-False and Logical Selection divisions. The remainder were graded by a competent assistant. The scores were all computed on the number of right responses.

Frequency distributions were made from these results, Central tendencies and measures of variability were calculated. This was done for each division of the test and for each form

---

<sup>1</sup> See Appendix--Test Copy--Page 3

of the test. Reliability coefficients were calculated on Forms A and B considered as a unit and for each of the divisions of each form considered as units.

Frequency distribution tables, frequency polygons and scattergrams for the computations of the reliability coefficient are presented on the following pages.

Table VII (a) Frequency Distribution of total scores made on Forms A and B in the Revised Edition of the Geometry Test.

| Scores  | Frequencies<br>Form A | Frequencies<br>Form B |
|---------|-----------------------|-----------------------|
| 115-119 | 1                     |                       |
| 110-114 |                       | 2                     |
| 105-109 | 2                     | 2                     |
| 100-104 |                       | 1                     |
| 95-99   | 2                     | 4                     |
| 90-94   | 8                     | 2                     |
| 85-89   | 13                    | 9                     |
| 80-84   | 21                    | 14                    |
| 75-79   | 49                    | 36                    |
| 70-74   | 64                    | 54                    |
| 65-69   | 121                   | 99                    |
| 60-64   | 152                   | 127                   |
| 55-59   | 167                   | 164                   |
| 50-54   | 152                   | 185                   |
| 45-49   | 138                   | 158                   |
| 40-44   | 88                    | 112                   |
| 35-39   | 52                    | 95                    |
| 30-34   | 32                    | 35                    |
| 25-29   | 19                    | 17                    |
| 20-24   | 5                     | 5                     |
| 15-19   | 1                     | 1                     |
|         | N-1087                | N-1122                |
|         | Md-56.6               | Md-53.7               |
|         | MN-56.8               | Mn-54.4               |
|         | $\sigma = 13.5$       | $\sigma = 13.0$       |

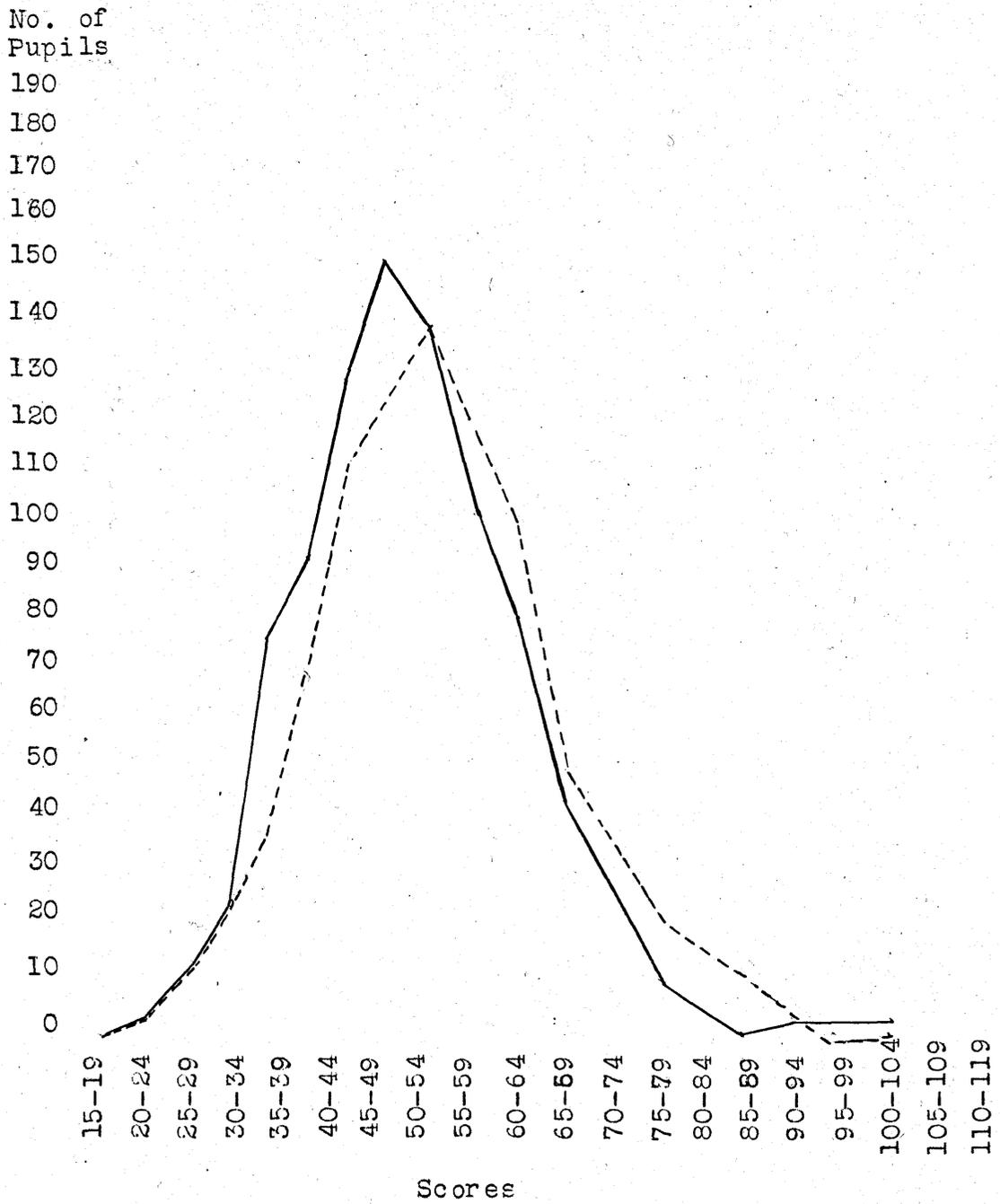


Fig. 1 Graphic comparison of distribution of total scores made on Forms A and B of Geometry Test

————— Form A  
----- Form B

Table VII (b) Frequency Distribution of total scores made on the True-False Divisions of Forms A and B of Geometry Test.

| Scores | Frequencies<br>Form A | Frequencies<br>Form B |
|--------|-----------------------|-----------------------|
| 70-72  |                       | 1                     |
| 67-69  | 2                     | 1                     |
| 64-66  |                       | 2                     |
| 61-63  | 2                     | 4                     |
| 58-60  | 3                     | 5                     |
| 55-57  | 12                    | 6                     |
| 52-54  | 19                    | 15                    |
| 49-51  | 28                    | 34                    |
| 46-48  | 58                    | 64                    |
| 43-45  | 88                    | 77                    |
| 40-42  | 141                   | 126                   |
| 37-39  | 160                   | 144                   |
| 34-36  | 128                   | 137                   |
| 31-33  | 124                   | 146                   |
| 28-30  | 116                   | 118                   |
| 25-27  | 87                    | 109                   |
| 22-24  | 47                    | 71                    |
| 19-21  | 41                    | 35                    |
| 16-18  | 20                    | 14                    |
| 13-15  | 5                     | 8                     |
| 10-12  | 4                     | 3                     |
| 7-0    |                       | 2                     |
|        | N-1085                | N-1122                |
|        | Md-36.3               | Md-35.2               |
|        | Mn-35.3               | Mn-34.8               |
|        | $\sigma = 8.7$        | $\sigma = 8.7$        |

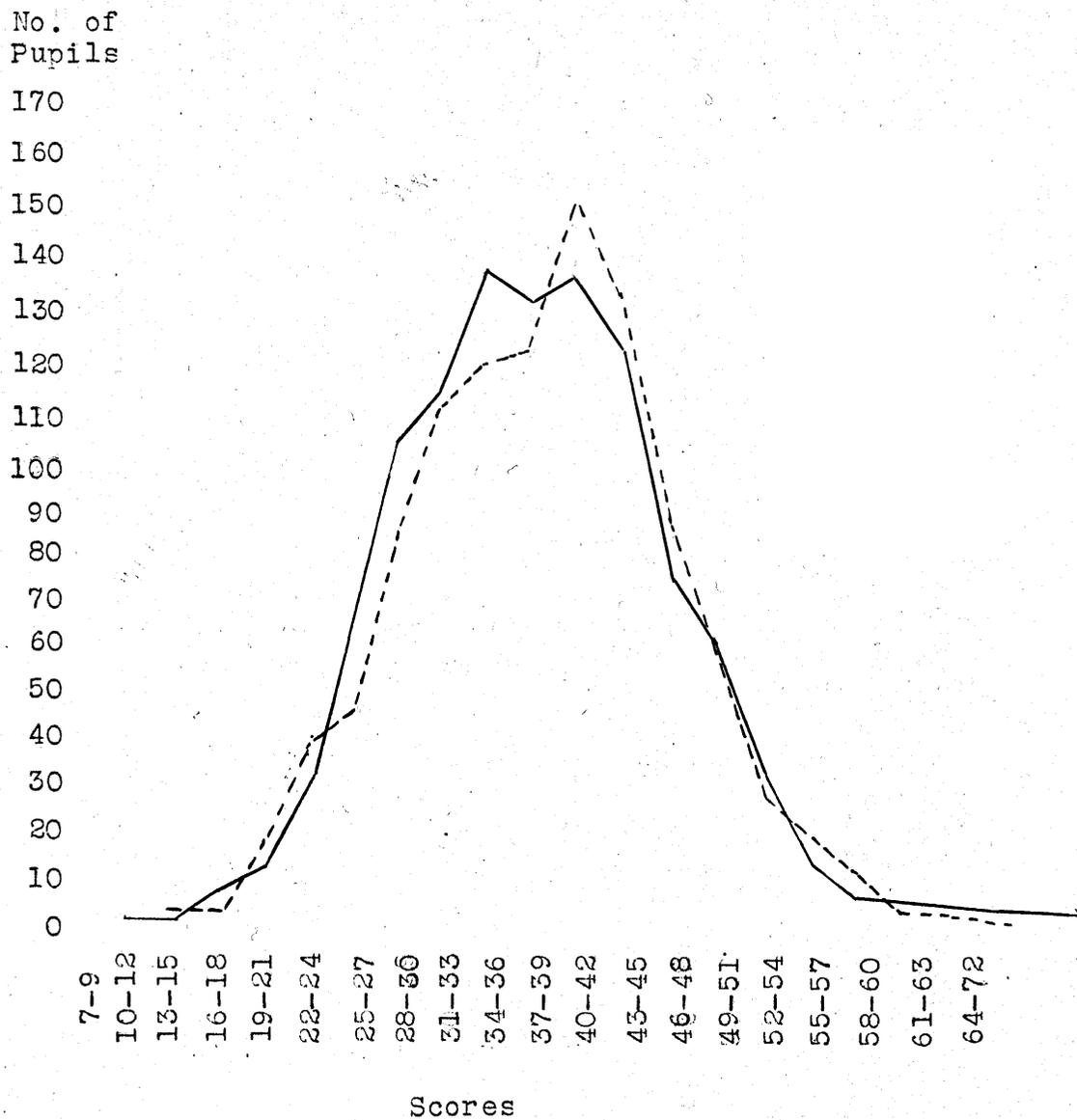


Fig. 2 Graphic comparison of distribution of scores made on True-False Section of Forms A and B of Geometry Test.

\_\_\_\_\_ Form A  
 ----- Form B

Table VII (c) Frequency Distribution of total scores made on the Logical Selection Division of Forms A and B of Geometry Test.

| Scores | Frequencies<br>Form A | Frequencies<br>Form B |
|--------|-----------------------|-----------------------|
| 29     | 1                     |                       |
| 28     |                       |                       |
| 27     |                       |                       |
| 26     |                       |                       |
| 25     | 1                     |                       |
| 24     |                       |                       |
| 23     |                       | 1                     |
| 22     | 1                     | 2                     |
| 21     |                       |                       |
| 20     | 6                     | 2                     |
| 19     | 12                    | 5                     |
| 18     | 15                    | 4                     |
| 17     | 12                    | 16                    |
| 16     | 33                    | 17                    |
| 15     | 46                    | 27                    |
| 14     | 81                    | 47                    |
| 13     | 74                    | 63                    |
| 12     | 105                   | 73                    |
| 11     | 111                   | 97                    |
| 10     | 136                   | 129                   |
| 9      | 116                   | 121                   |
| 8      | 121                   | 154                   |
| 7      | 71                    | 131                   |
| 6      | 60                    | 104                   |
| 5      | 32                    | 61                    |
| 4      | 29                    | 45                    |
| 3      | 18                    | 13                    |
| 2      | 1                     | 6                     |
| 1      | 2                     | 3                     |
| 0      | 1                     | 1                     |
|        | N-1085                | N-1122                |
|        | Md-10.6               | Md- 9.3               |
|        | Mn-10.3               | Mn- 9.1               |
|        | $\sigma$ - 3.3        | $\sigma$ - 3.3        |

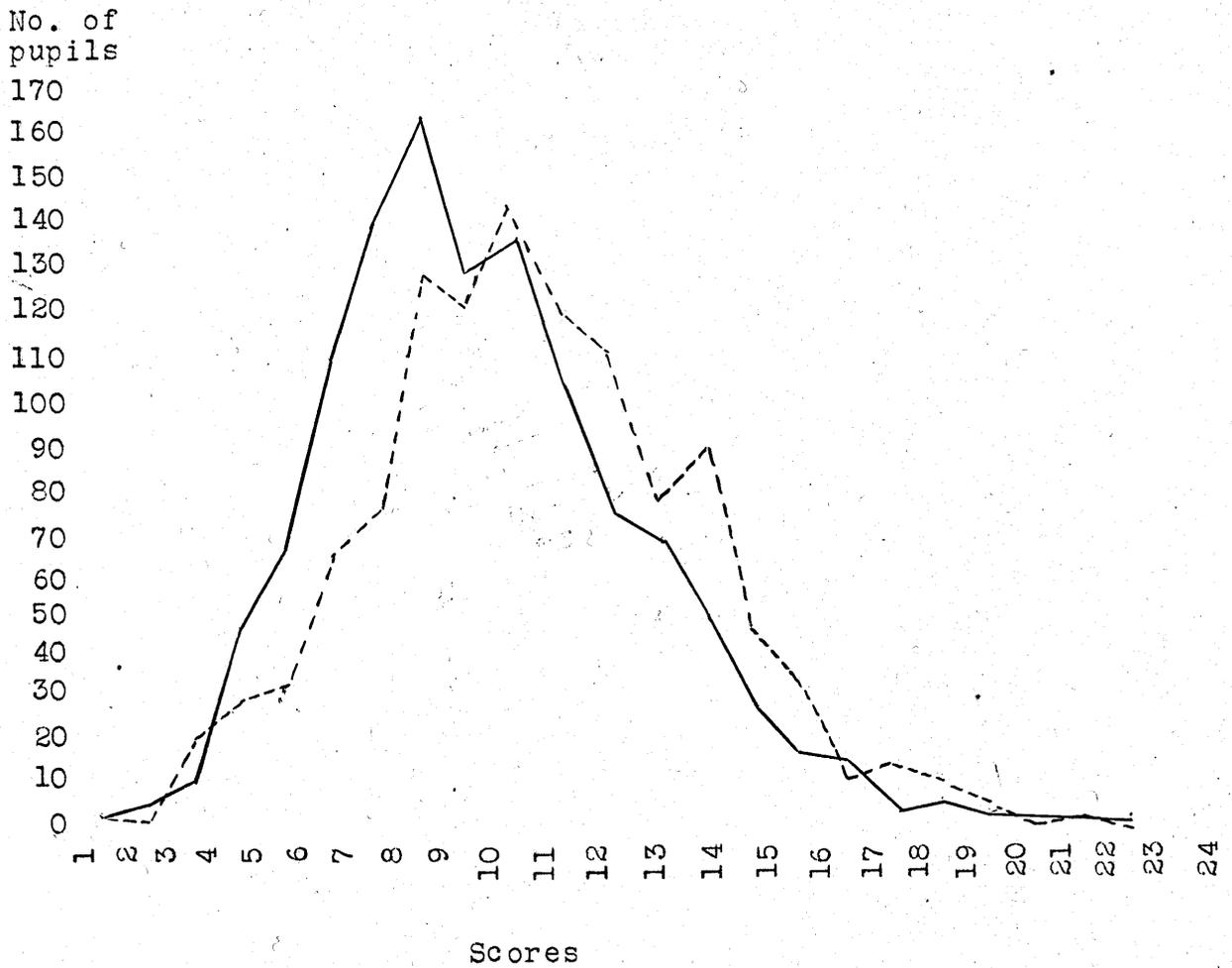


Fig. 3 Graphic comparison of total scores made on Logical Selection Division of Forms A and B of the Geometry Test

Table VII (d) Frequency Distribution of total scores made on the Problem Division of Forms A and B of Geometry Test.

| Scores | Frequencies<br>Form A | Frequencies<br>Form B |
|--------|-----------------------|-----------------------|
| 26     |                       | 1                     |
| 25     | 3                     | 1                     |
| 24     | 1                     |                       |
| 23     |                       | 2                     |
| 22     |                       | 2                     |
| 21     | 8                     | 6                     |
| 20     | 11                    | 3                     |
| 19     | 19                    | 11                    |
| 18     | 16                    | 14                    |
| 17     | 38                    | 28                    |
| 16     | 33                    | 24                    |
| 15     | 53                    | 37                    |
| 14     | 80                    | 56                    |
| 13     | 95                    | 85                    |
| 12     | 82                    | 88                    |
| 11     | 83                    | 106                   |
| 10     | 102                   | 119                   |
| 9      | 100                   | 103                   |
| 8      | 109                   | 108                   |
| 7      | 60                    | 83                    |
| 6      | 73                    | 86                    |
| 5      | 46                    | 58                    |
| 4      | 32                    | 48                    |
| 3      | 26                    | 29                    |
| 2      | 9                     | 15                    |
| 1      | 5                     | 6                     |
| 0      | 1                     | 3                     |

N-1085

N-1122

Md-10.8

Md-10.1

Mn-10.5

Mn- 9.8

 $\sigma = 2.9$  $\sigma = 2.7$

No. of pupils

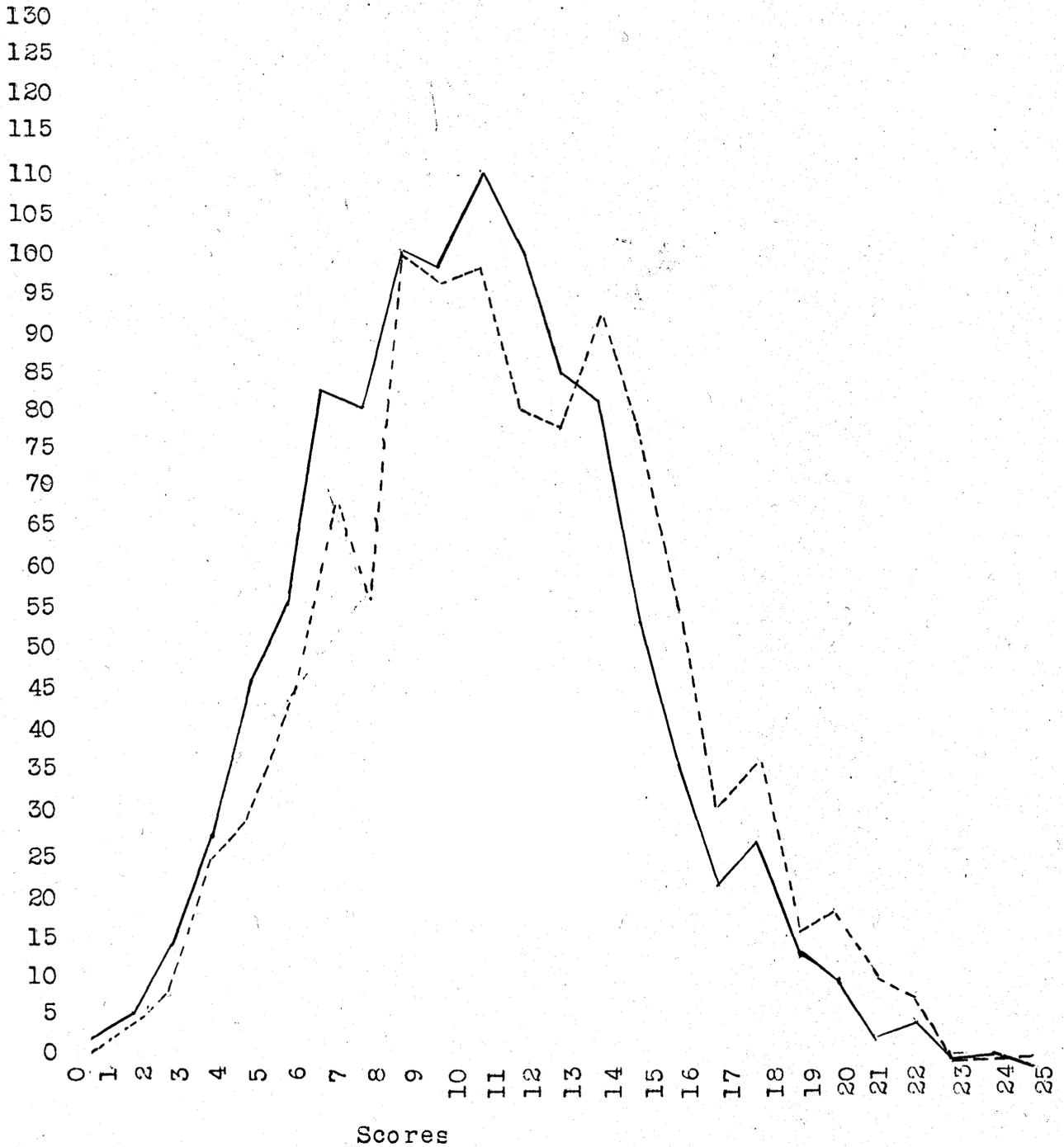


Fig. 4 Graphic comparison of scores made on Problem Section of Forms A and B of Geometry Test.

————— Form A

----- Form B

Fig. 5 Scattergram of total scores of Form A and Form B of  
Geometry Test

|        |  | Form A |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |     |     |
|--------|--|--------|----|----|----|----|----|-----|-----|-----|-----|----|----|----|----|----|----|-----|-----|
|        |  | 15     | 20 | 25 | 30 | 35 | 40 | 45  | 50  | 55  | 60  | 65 | 70 | 75 | 80 | 85 | 90 | 95  | f   |
|        |  | 19     | 24 | 29 | 34 | 39 | 44 | 49  | 54  | 59  | 64  | 69 | 74 | 79 | 84 | 89 | 94 | 119 |     |
| 95-114 |  |        |    |    |    |    |    |     |     |     |     |    |    | 1  |    |    | 2  | 4   | 7   |
| 90-94  |  |        |    |    |    |    |    |     |     |     |     |    |    |    | 1  |    | 1  |     | 2   |
| 85-89  |  |        |    |    |    |    |    | 1   |     |     | 1   |    | 3  | 3  |    |    |    |     | 8   |
| 80-84  |  |        |    |    |    |    |    |     |     |     |     | 1  | 3  | 2  | 2  | 2  | 1  | 1   | 12  |
| 75-79  |  |        |    |    |    |    |    | 1   |     | 2   | 4   | 7  | 6  | 7  | 2  | 1  |    |     | 30  |
| 70-74  |  |        |    | 1  |    |    |    |     | 2   | 2   | 8   | 10 | 12 | 3  | 6  | 2  | 2  |     | 48  |
| 65-69  |  |        |    |    |    |    | 1  | 5   | 5   | 8   | 19  | 23 | 13 | 8  | 3  | 5  |    |     | 90  |
| 60-64  |  |        |    |    |    |    | 4  | 9   | 13  | 17  | 21  | 19 | 8  | 6  | 2  | 2  |    |     | 101 |
| 55-59  |  |        |    | 1  | 1  | 5  | 15 | 15  | 37  | 37  | 13  | 8  | 2  | 1  |    |    |    |     | 135 |
| 50-54  |  |        |    | 3  | 7  | 17 | 26 | 35  | 28  | 21  | 7   | 5  | 2  | 1  |    | 1  |    |     | 153 |
| 45-49  |  |        |    | 2  | 5  | 16 | 23 | 35  | 18  | 14  | 11  | 2  | 2  |    |    |    |    |     | 128 |
| 40-44  |  |        |    | 4  | 3  | 9  | 14 | 19  | 16  | 17  | 8   | 2  | 2  | 2  |    |    |    |     | 96  |
| 35-39  |  |        |    | 4  | 6  | 16 | 16 | 16  | 6   | 11  | 1   | 4  | 2  |    |    |    |    |     | 82  |
| 30-34  |  |        | 1  | 3  | 11 | 4  | 3  | 6   | 1   |     | 1   |    |    |    |    |    |    |     | 30  |
| 25-29  |  | 1      | 2  | 3  | 5  | 2  | 2  | 1   | 1   |     |     |    |    |    |    |    |    |     | 17  |
| 20-24  |  |        | 2  | 1  |    | 1  |    |     |     |     |     |    |    |    |    |    |    |     | 4   |
| 15-19  |  |        |    |    |    |    |    |     | 1   |     |     |    |    |    |    |    |    |     | 1   |
| f      |  | 1      | 5  | 15 | 32 | 45 | 78 | 121 | 131 | 140 | 134 | 98 | 61 | 38 | 21 | 12 | 7  | 5   |     |

N=944

$$r = .70 \pm .0107$$

$$\sigma_y = 13.35$$

$$\sigma_x = 13.70$$

Fig. 6 Scattergram of total scores of the True-False Sections  
of Form A and Form B of Geometry Test

|        |       | Form A |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |     |
|--------|-------|--------|----|----|----|----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|-----|
|        |       | 10     | 13 | 16 | 19 | 22 | 25  | 28  | 31  | 34  | 37  | 40 | 43 | 46 | 49 | 52 | 55 | f  |     |
| Form B | 61-63 | 12     | 15 | 18 | 21 | 24 | 27  | 30  | 33  | 36  | 39  | 42 | 45 | 48 | 51 | 54 | 69 | 7  |     |
|        | 58-60 |        |    |    |    |    |     |     |     |     |     |    |    |    | 1  | 1  | 2  | 1  | 5   |
|        | 55-57 |        |    |    |    |    |     |     |     | 1   | 1   |    |    |    | 1  | 1  | 1  |    | 5   |
|        | 52-54 |        |    |    |    |    |     |     |     |     |     | 1  | 1  | 4  | 2  | 1  | 1  | 2  | 12  |
|        | 49-51 |        |    |    |    |    |     | 1   |     | 3   | 4   | 6  | 4  | 2  | 5  | 1  | 1  |    | 27  |
|        | 46-48 |        |    |    | 1  |    |     | 1   | 4   | 3   | 7   | 16 | 10 | 7  | 3  | 1  | 4  |    | 56  |
|        | 43-45 |        |    |    |    |    | 3   | 4   | 5   | 7   | 13  | 11 | 10 | 5  | 1  | 2  | 2  |    | 63  |
|        | 40-42 |        |    |    | 1  | 3  | 6   | 13  | 14  | 21  | 22  | 10 | 9  | 1  | 2  | 1  |    |    | 106 |
|        | 37-39 |        |    | 1  | 2  | 7  | 13  | 13  | 23  | 27  | 21  | 7  | 5  | 3  |    | 1  |    |    | 123 |
|        | 34-36 |        |    | 1  | 2  | 4  | 10  | 14  | 17  | 19  | 16  | 12 | 9  | 6  | 2  | 3  | 1  |    | 116 |
|        | 31-33 |        |    | 1  | 1  | 9  | 12  | 18  | 19  | 14  | 14  | 15 | 8  | 3  | 2  | 1  |    |    | 117 |
|        | 28-30 |        | 1  | 2  | 3  | 6  | 10  | 20  | 15  | 17  | 14  | 7  | 2  | 1  | 2  | 1  |    |    | 101 |
|        | 25-27 |        | 1  | 3  | 9  | 5  | 17  | 13  | 8   | 7   | 11  | 9  | 3  |    | 1  |    |    |    | 87  |
|        | 22-24 |        | 1  | 3  | 8  | 7  | 12  | 8   | 5   | 7   | 5   | 3  | 2  |    |    | 1  |    |    | 62  |
|        | 19-21 | 2      |    | 4  | 6  | 6  | 5   | 4   | 2   | 1   | 1   | 2  |    |    |    |    |    |    | 33  |
|        | 16-18 |        | 2  | 1  | 3  |    |     | 4   |     | 1   | 2   |    |    |    |    |    |    |    | 13  |
| 9-15   | 1     |        |    | 3  | 1  |    |     |     | 2   | 1   | 2   |    |    |    |    |    |    | 10 |     |
| f      | 3     | 5      | 18 | 36 | 42 | 79 | 106 | 102 | 119 | 137 | 127 | 69 | 42 | 24 | 16 | 18 |    |    |     |

N = 943

r = .56 ± .015

$\sigma_y = 9.0$

$\sigma_x = 8.7$

Fig. 7 Scattergram of total scores of the Logical Selection  
Sections of Form A and Form B of the Geometry Test.

|        |    | Form A |    |    |    |     |     |     |    |    |    |    |    |    |    |    |    |    |     |  |
|--------|----|--------|----|----|----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|-----|--|
|        |    | 3      | 4  | 5  | 6  | 7   | 8   | 9   | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | f   |  |
| Form B | 19 |        |    |    |    |     |     |     |    |    | 1  | 1  | 1  |    | 2  | 1  | 1  | 2  | 9   |  |
|        | 18 |        |    |    |    |     |     |     |    |    |    | 2  |    |    |    |    |    | 1  | 3   |  |
|        | 17 |        |    | 1  |    |     |     |     |    | 1  | 1  |    | 1  | 2  | 3  | 2  | 2  | 1  | 14  |  |
|        | 16 |        |    |    |    |     | 2   | 1   |    | 1  | 2  | 1  | 1  | 2  |    |    | 1  | 1  | 12  |  |
|        | 15 |        |    | 1  | 2  | 1   | 1   | 1   | 3  | 2  | 3  | 3  | 3  | 1  | 3  |    |    |    | 24  |  |
|        | 14 |        |    |    |    |     | 4   | 3   | 3  | 4  | 5  | 3  | 3  | 6  | 3  | 1  | 1  | 2  | 38  |  |
|        | 13 |        | 1  |    | 2  |     | 2   | 2   | 6  | 4  | 5  | 5  | 10 | 6  | 6  | 1  | 1  |    | 51  |  |
|        | 12 |        | 1  | 1  | 3  | 3   | 2   | 4   | 4  | 4  | 9  | 9  | 5  | 5  | 4  | 1  |    | 1  | 57  |  |
|        | 11 |        |    |    | 4  | 3   | 10  | 10  | 8  | 10 | 10 | 10 | 8  | 3  | 2  | 2  | 2  | 1  | 84  |  |
|        | 10 |        |    |    | 1  | 5   | 8   | 12  | 20 | 17 | 14 | 5  | 12 | 4  | 6  |    |    | 1  | 107 |  |
|        | 9  | 1      |    | 2  | 5  | 2   | 9   | 5   | 14 | 13 | 18 | 12 | 7  | 9  | 3  | 2  | 1  | 1  | 104 |  |
|        | 8  | 1      | 4  | 3  | 4  | 11  | 18  | 31  | 18 | 8  | 11 | 3  | 9  | 2  | 2  | 1  | 2  | 1  | 129 |  |
|        | 7  | 5      | 2  | 5  | 8  | 10  | 18  | 19  | 14 | 12 | 7  | 4  | 4  | 2  | 1  |    |    | 1  | 112 |  |
|        | 6  | 4      | 5  | 4  | 11 | 6   | 14  | 8   | 14 | 9  | 4  | 3  | 4  | 1  |    |    |    |    | 87  |  |
| 5      | 2  | 5      | 6  | 7  | 6  | 5   | 7   | 5   | 3  | 1  | 1  | 2  | 2  |    |    |    |    | 52 |     |  |
| 4      | 1  | 1      | 4  | 1  | 5  | 8   | 5   | 6   | 2  | 1  | 2  | 2  |    |    |    |    |    | 38 |     |  |
| 3      | 6  | 4      | 2  | 2  | 4  | 1   |     |     |    | 1  |    |    | 2  |    |    |    |    | 22 |     |  |
| f      | 20 | 23     | 29 | 50 | 58 | 102 | 108 | 115 | 91 | 92 | 64 | 74 | 45 | 35 | 11 | 11 | 15 |    |     |  |

N=943

$$r = .50 \pm .0161$$

$$\sigma_y = 3.3$$

$$\sigma_x = 3.5$$

Fig. 8 Scattergram of total scores of the Problem Sections of Form A and Form B of the Geometry Test

|        |    | Form A |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |
|--------|----|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|--|
|        |    | 3      | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | f  |  |  |
| Form B | 20 |        |    |    |    |    |    |    |    |    | 1  |    |    |    | 1  | 3  | 2  | 1  |    | 6  | 14 |  |  |
|        | 19 |        |    |    |    |    |    |    |    |    |    | 1  |    |    | 1  |    | 1  | 3  | 4  | 2  | 12 |  |  |
|        | 18 |        |    |    |    |    |    |    | 1  |    |    | 1  |    |    | 1  | 2  |    | 3  | 2  | 2  | 12 |  |  |
|        | 17 |        |    |    |    |    | 1  |    | 1  |    | 2  | 4  | 4  | 2  | 4  | 6  | 1  | 3  |    | 1  | 29 |  |  |
|        | 16 |        |    |    | 1  |    |    |    |    |    |    | 5  | 6  | 2  | 2  | 4  | 4  | 3  | 1  |    | 23 |  |  |
|        | 15 |        |    |    |    |    | 1  |    | 1  | 2  | 3  | 6  | 3  | 6  | 3  | 3  | 2  | 1  | 1  |    | 31 |  |  |
|        | 14 |        |    |    |    | 1  | 2  |    | 7  | 4  | 6  | 10 | 4  | 7  | 3  | 2  |    | 1  | 1  |    | 44 |  |  |
|        | 13 |        |    | 1  |    | 1  | 2  | 2  | 6  | 5  | 8  | 11 | 10 | 6  | 6  | 5  | 1  | 3  | 1  |    | 67 |  |  |
|        | 12 |        |    | 1  | 1  |    | 1  | 4  | 9  | 7  | 12 | 17 | 9  | 10 | 3  | 4  | 1  | 2  |    |    | 75 |  |  |
|        | 11 |        |    | 2  | 2  | 2  | 7  | 11 | 13 | 9  | 11 | 6  | 10 | 3  | 3  | 2  |    |    |    |    | 92 |  |  |
|        | 10 |        |    | 2  |    | 4  | 13 | 9  | 16 | 13 | 12 | 6  | 11 | 5  | 1  | 2  | 3  |    |    |    | 95 |  |  |
|        | 9  |        |    | 5  | 5  | 3  | 8  | 9  | 13 | 6  | 7  | 10 | 7  | 3  |    |    |    |    |    |    | 72 |  |  |
|        | 8  | 2      | 1  | 3  | 8  | 8  | 17 | 12 | 9  | 3  | 4  | 2  | 4  | 2  |    | 1  | 1  |    |    |    | 85 |  |  |
|        | 7  | 3      | 2  | 5  | 12 | 3  | 10 | 12 | 7  | 10 | 1  | 4  | 2  |    |    |    |    |    |    |    | 69 |  |  |
|        | 6  | 5      | 3  | 6  | 9  | 11 | 8  | 14 | 5  | 7  | 2  |    | 1  | 1  |    |    |    |    |    |    | 76 |  |  |
| 5      | 5  | 3      | 6  | 8  | 9  | 13 | 5  | 2  | 1  | 1  |    |    |    |    |    |    |    |    |    | 53 |    |  |  |
| 4      | 6  | 8      | 3  | 10 | 5  | 5  | 6  |    | 2  | 1  |    |    |    |    |    |    |    |    |    | 46 |    |  |  |
| 3      | 5  | 3      | 5  | 2  | 1  | 8  | 2  |    |    |    |    |    |    |    |    |    |    |    |    | 26 |    |  |  |
| 2      | 10 | 5      | 5  | 1  | 1  | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    | 23 |    |  |  |
| f      | 36 | 25     | 44 | 59 | 49 | 97 | 84 | 90 | 69 | 71 | 83 | 71 | 47 | 28 | 34 | 16 | 20 | 10 | 11 |    |    |  |  |

N=944

$$r = .76 \pm .006$$

$$\sigma_y = 4.1$$

$$\sigma_x = 4.2$$

A summary of the Central Tendencies and Measures of Variability of the Revised Edition of the Achievement Test in Plane Geometry is shown here.

| Forms | N    | Median | Mean | Sigma |
|-------|------|--------|------|-------|
| A     | 1085 | 56.6   | 56.8 | 13.5  |
| B     | 1122 | 56.8   | 54.4 | 13.0  |

#### Reliability Coefficients

##### Between Forms A and B

| Test                   | N   | "r"             |
|------------------------|-----|-----------------|
| Complete               | 944 | .70 $\pm$ .0107 |
| True-False Div.        | 943 | .56 $\pm$ .015  |
| Logical Selection Div. | 943 | .50 $\pm$ .016  |
| Problem Division       | 944 | .76 $\pm$ .006  |

An additional analysis was made by scoring the true-false sections by the 'right minus wrong method' instead of the 'number right method'. The reliability coefficient between Forms A and B of the complete test was again computed. This method of scoring raised the reliability coefficient seven points from .70 to .77. This computation was based on 937 cases.

It was not possible to compute the correction for attenuation because neither form of the test had been repeated with the same groups of students but, if it had been possible, the reliability coefficient would probably have been significantly higher. The writer has some personal ideas for explanation of the low coefficient in the Logical Selection Division but has no scientific conclusions to offer.

## CHAPTER III

## SUMMARY AND CONCLUSION

The analysis of six geometry text books was the chief source of content for this Achievement Test in Plane Geometry. No element was included unless the principle involved was contained in all of the texts. Two equivalent forms of the test were constructed. Each form consisted of three types of objective tests namely True-False, Logical Selections, and Problems.

The experiment extended over a period of two years. The First Experimental Edition was sent out at the close of the school year in 1925. Test results were tabulated, analyzed and selection of elements made on the basis of returns from approximately 825 students for each form. Test elements were scaled in order of difficulty. The revised edition was sent out near the close of the school year of 1926. Test results were analyzed and norms based on approximately 1100 students for each form. Reliability coefficients were computed on approximately 950 students.

The test was derived for the purpose of measuring the geometry achievement of students who had completed the course in plane geometry. The administrators of the test were the geometry teachers.

On the basis of the test criteria used and the standardization of the test, the writer concludes the test will serve all the purposes ordinarily served by standardized tests which give

valid, reliable and comparable measures of defined achievement. The test should prove of particular value in making comparisons between the achievements of different classes in the same or in different schools at the same or at different times; between different methods of instruction; between the work of different teachers; or between the efficiency of different text books.

A P P E N D I X

Fig. 10 Scattergram of total scores of Form A and Form B of Geometry Test when True-False Sections were scored Right,

Wrong, Minus

|        |         | Form A |    |    |    |     |     |     |    |    |    |    |    |    |    |    |    |    | f   |     |
|--------|---------|--------|----|----|----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|-----|-----|
|        |         | 5      | 15 | 20 | 25 | 30  | 35  | 40  | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 100 |     |
|        |         | 14     | 19 | 24 | 29 | 34  | 39  | 44  | 49 | 54 | 59 | 64 | 69 | 74 | 79 | 84 | 89 | 99 | 109 |     |
| Form B | 100-115 |        |    |    |    |     |     |     |    |    |    |    |    |    |    | 1  |    | 2  |     | 3   |
|        | 85-99   |        |    |    |    |     |     |     |    |    |    |    |    |    |    | 1  | 2  |    |     | 3   |
|        | 80-84   |        |    |    |    |     |     |     |    |    |    | 1  | 3  |    |    | 1  | 1  |    | 1   | 7   |
|        | 75-79   |        |    |    |    |     |     | 1   |    |    | 1  |    | 3  | 3  | 1  |    | 1  |    |     | 10  |
|        | 70-74   |        |    |    |    |     |     |     |    |    | 1  | 3  | 1  | 1  |    | 1  |    |    |     | 7   |
|        | 65-69   |        |    |    |    |     | 1   |     | 1  | 3  | 5  | 6  | 2  | 1  |    |    |    |    |     | 19  |
|        | 60-64   |        |    |    |    |     |     |     | 1  | 4  | 1  | 6  | 8  | 4  | 2  | 1  | 1  |    |     | 28  |
|        | 55-59   |        |    |    | 1  | 1   |     |     | 1  | 7  | 13 | 11 | 7  | 2  | 1  | 1  |    |    |     | 45  |
|        | 50-54   |        |    |    | 3  | 2   | 6   | 14  | 12 | 10 | 6  | 9  | 2  | 2  |    |    |    |    |     | 66  |
|        | 45-49   |        | 1  | 1  | 8  | 9   | 10  | 19  | 25 | 19 | 10 | 4  | 4  | 3  |    |    |    |    |     | 113 |
|        | 40-44   |        | 1  | 3  | 5  | 12  | 18  | 23  | 20 | 12 | 7  | 3  | 3  |    |    |    |    |    |     | 107 |
|        | 35-39   |        | 5  | 5  | 15 | 21  | 27  | 17  | 10 | 10 | 2  | 1  |    |    |    |    |    |    |     | 113 |
|        | 30-34   | 2      | 6  | 12 | 24 | 19  | 25  | 19  | 8  | 6  | 2  |    | 1  |    |    |    |    |    |     | 124 |
| 25-29  | 4       | 10     | 21 | 11 | 20 | 24  | 11  | 3   | 1  | 3  |    |    |    |    |    |    |    |    | 108 |     |
| 20-24  | 9       | 12     | 16 | 21 | 11 | 6   | 6   | 3   |    |    |    |    |    |    |    |    |    |    | 84  |     |
| 15-19  | 10      | 14     | 10 | 6  | 5  | 7   | 3   |     |    |    |    |    |    |    |    |    |    |    | 55  |     |
| 5-14   | 13      | 15     | 6  | 3  | 4  | 1   | 1   |     |    |    |    |    |    |    |    |    |    |    | 43  |     |
| f      |         | 38     | 64 | 74 | 95 | 104 | 125 | 116 | 93 | 75 | 54 | 42 | 25 | 13 | 4  | 6  | 2  | 2  | 1   |     |

N = 935

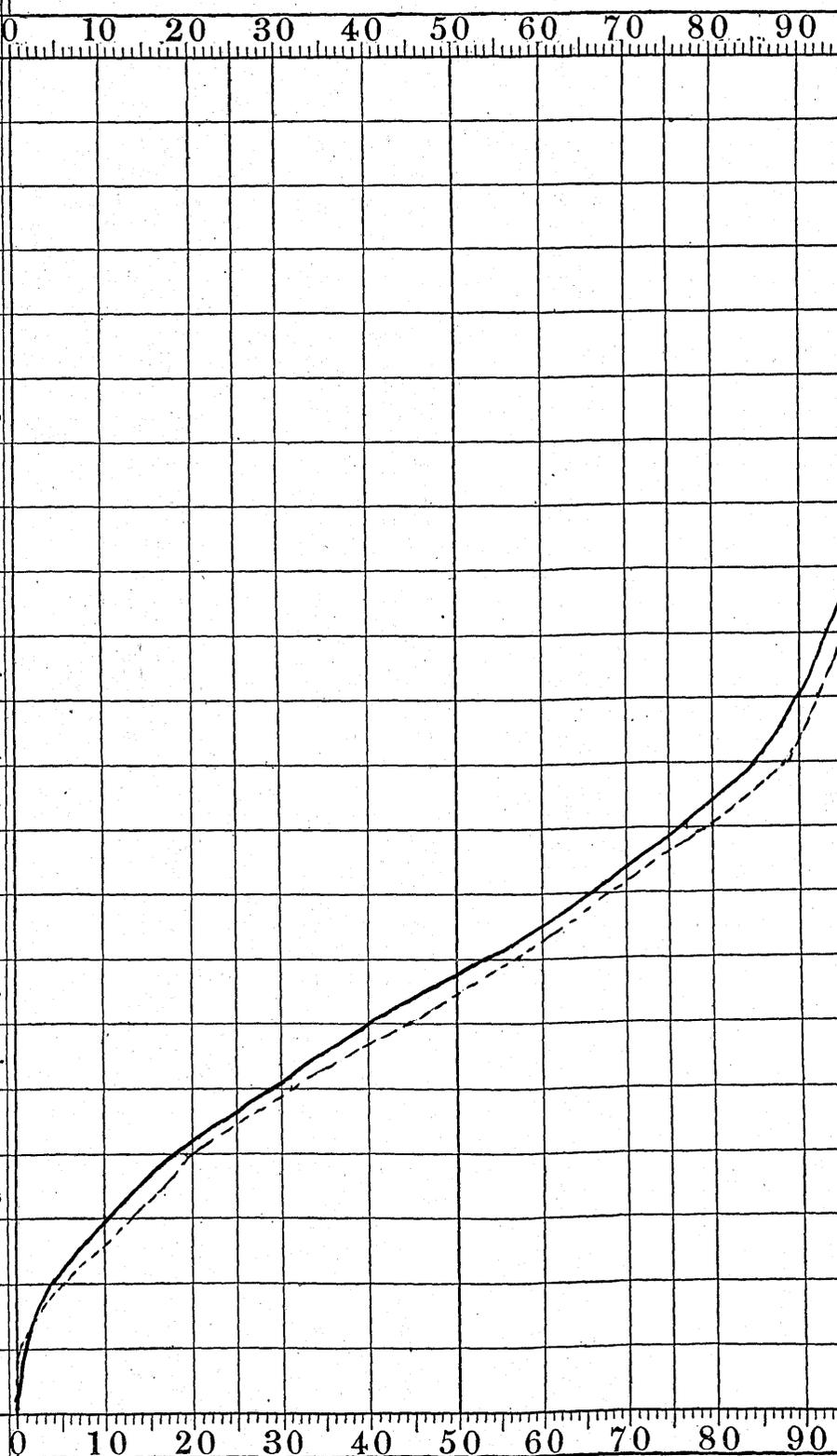
$r = .77 \pm .008$

$\sigma_x = 15.7$

$\sigma_y = 15.5$

UNIVERSAL PERCENTILE GRAPH

|                |           |            |           |           |  |     |
|----------------|-----------|------------|-----------|-----------|--|-----|
| Grade or Class |           |            |           |           | Examination Complete Test when True-False    |     |
| Number         | 1083      |            | 1119      |           | School or College Section Scored Right Minus |     |
| Date of Exam.  | May 1926  |            | May 1926  |           | Examiner Wrong                               |     |
| Form Used      | Form A    |            | Form B    |           | Percentile Graph                             |     |
| Score          | Tally-ing | Sub-totals | Per cents | Tally-ing |  |     |
| 105-           |           |            |           |           |  |     |
| 109            | 1         | 1083       | 100       | 1         | 1119   | 100 |
| 100-           |           |            |           |           |  |     |
| 104            | 1         | 1082       | 99        | 1         | 1118   | 99  |
| 95-99          | 2         | 1081       | 99        | 0         |  |     |
| 90-94          | 0         |            |           | 2         | 1117   | 99  |
| 85-89          | 2         | 1079       | 99        | 2         | 1115   | 99  |
| 80-84          | 6         | 1077       | 98        | 7         | 1113   | 98  |
| 75-79          | 4         | 1071       | 98        | 9         | 1106   | 98  |
| 70-74          | 12        | 1067       | 98        | 8         | 1097   | 98  |
| 65-69          | 27        | 1055       | 97        | 19        | 1089   | 97  |
| 60-64          | 44        | 1028       | 94        | 30        | 1070   | 95  |
| 55-59          | 63        | 984        | 90        | 45        | 1040   | 92  |
| 50-54          | 86        | 921        | 84        | 84        | 995  | 88  |
| 45-49          | 107       | 835        | 77        | 136       | 911  | 81  |
| 40-44          | 139       | 728        | 67        | 127       | 775  | 69  |
| 35-39          | 147       | 589        | 54        | 145       | 648  | 57  |
| 30-34          | 127       | 442        | 40        | 154       | 503  | 45  |
| 25-29          | 115       | 315        | 29        | 130       | 349  | 31  |
| 20-24          | 79        | 200        | 18        | 105       | 219  | 19  |
| 15-19          | 72        | 121        | 11        | 67        | 114  | 10  |
| 10-14          | 35        | 49         | 4         | 36        | 47   | 4   |
| 5-9            | 14        | 14         | 1         | 11        | 11   | 100 |
| Class Medians  | 38        |            |           | 37        |  |     |



————— Form A  
 - - - - - Form B

**Finding the subtotals.** Begin at the bottom of the column of frequencies and place in the square to the right of each frequency the sum of the frequencies up to and including that frequency. In the subtotal column under 6th grade (Fig. 1) there is 1 score in the first interval, a subtotal of 2 to and including the second interval, a subtotal of 4 to and including the third interval, etc., and 50 to and including the last interval. This last "subtotal" (50) should equal the number of pupils in the class, as entered at the top of the column.

**Reducing subtotals to per cents.** In the column headed "Per cents" write opposite each subtotal the per cent that subtotal is of the whole number of pupils in the class. In Figure 1 under Grade 6, 1 is 2 per cent of 50, 2 is 4 per cent of 50, 4 is 8 per cent of 50, etc., and 50 is 100 per cent of 50.

It is not necessary to reduce subtotals to per cents when use is made of the Scale Chart A printed opposite the Percentile Graph. The method of using the scale charts is given below.

**Locating the points in the graph.** First place a dot at the left edge of the graph on the horizontal line representing the lower limit of the lowest score interval containing a score. Next, place on the next line above, a dot having a distance to the right of the left margin of the graph equal to the lowest number in the "Per cents" column, according to the scale at the foot of the graph. (In Figure 1 the second dot in the percentile curve for the 6th grade is placed 2 units from the edge of the graph.) Next, place on the next line above, a dot having a distance to the right of the margin representing the next per cent, etc. (The third dot represents 4 per cent, etc., and the last dot represents 100 per cent.)

**Use of the scale charts.** Scale Chart A on the back of each Percentile Graph is provided to simplify the process of plotting the points in the graph. It is used as follows: Let us take the case of the 6th grade, there being 50 pupils in the grade. Find Scale 50 on Scale Chart A, according to the numbers at the right. This line is divided into exactly 50 equal parts by the slanting lines in the chart. Each space, therefore, represents  $\frac{1}{50}$  or 2 per cent of the width of the graph. The second dot in the 6th-grade percentile curve (Fig. 1) is to be placed just  $\frac{1}{50}$  of the distance to the right of the margin. This is just 1 space on Scale 50. The third dot is to be placed just 2 spaces to the right of the margin, the fourth point just 4 spaces to the right of the margin, etc., according to Scale 50. By the use of Scale 41, the points have been plotted in the same way for the 7th grade.

By detaching one of the copies of Scale Chart A, folding it on the proper scale, and applying it to the Percentile Graph, the width of the graph may be divided into any number of equal parts from 40 to 100. By letting 2 or 4 graduations represent 1 unit, or letting 1 graduation represent 2 units, the width of the graph may be divided into any number of equal parts from 10 to 200.

**Drawing the curve.** Draw a smooth curve through the dots plotted as described above. This is the percentile curve.

**Graduating the vertical scale.** Inasmuch as the Percentile Graph is arranged to be used with different tests having different ranges of scores, it is not possible to provide a scale on the 50-percentile line which will fit all cases. Scale Charts B to G are provided, therefore, opposite Scale Chart A for graduating the spaces between horizontal lines to scales corresponding to groupings of 1, 2, 3, 4, 5, and 10 units to the interval. By applying the appropriate

one of these scales to the Percentile Graph, the score represented by the point at which a percentile curve cuts the 50-percentile line, or any other percentile line, can be read to the nearest unit. To graduate the vertical scale of the Percentile Graph to correspond to a grouping in intervals of 5 units, as in Figure 1, use Scale Chart F; when intervals of 3 units are used, as in Figure 2, use Scale Chart D; etc.

**Finding the median score of a class.** The point where the percentile curve cuts the 50-percentile line represents the median score of the group.<sup>1</sup> In Figure 1 the median scores of the 6th and 7th grades are, respectively, 45 and 50.

**Finding the variability of the scores of a class.** The points at which the curve cuts the 25- and 75-percentile lines represent the lower and upper quartile scores of a distribution. The interval between these is the interquartile range — a very convenient measure of the scatter of the distributions. In Figure 1 the interquartile ranges for the 6th and 7th grades are, respectively, 14 and 13 points (6th grade from 38 to 52, and 7th grade from 43 to 56). This shows the variability of the scores of the two grades to be about equal. The variabilities of the scores of the two grades in Figure 2 differ considerably.

**Overlapping of classes.** It will be seen by a glance at the percentile curves in Figure 1 that the 7th grade is only slightly better than the 6th and that the distributions of scores of the two grades overlap very markedly. A convenient way of expressing this overlapping is to say that 31 per cent of the 7th grade fall below the median of the 6th, or that 31 per cent of the 6th grade exceed the median of the 7th. The overlapping is less marked in Figure 2.

**Percentile rank in class.** If an individual makes a score exceeding 75 per cent of the scores of his class, he is said to have a percentile rank of 75 in his class; and the same for other percentages. The percentile rank of any individual among the members of his class may be found from the percentile curve representing the scores of his class as follows: Suppose an individual in the 7th grade has made a score of 58. Find the point 58 on the vertical scale in the Percentile Graph and move the pencil horizontally to the point at the same height on the percentile curve for the 7th grade. This point represents on the horizontal scale a percentile rank of 80. The percentile rank of the individual among the members of his class is, therefore, 80, which means that his score exceeds the scores of 80 per cent of his class. A score of 58 represents a percentile rank of 90 among the members of the 6th grade.

**Use of the Percentile Graph in regrading.** A description of the use of the Percentile Graph in regrading and classification is given in the Manual of Directions for the Otis Classification Test,<sup>2</sup> page 49.

Those who wish a more thorough understanding of the meaning and use of the Percentile Graph — how it is related to other forms of graphic representation of distributions, how it may be used in finding the correspondence between scores in different tests, between scores and scholarship marks in order that these may be averaged, etc., are referred to the *Primer of Statistical Method* by Arthur S. Otis. This book is now in preparation and will be published by the World Book Company.

<sup>1</sup> The value so found may not be exactly the same as the median found in the usual way by counting to the middle paper in order of score, but if not, the median score found by means of the curve is considered to represent the distribution better and to be in that sense more nearly accurate.

<sup>2</sup> Published by World Book Company, Yonkers-on-Hudson, New York.

## BIBLIOGRAPHY

- Asher, W. "The Reliability of Tests Requiring Alternative Responses"  
Journal of Education Research, 1924, Vol. 9
- Barthelmess, H. M. "Reply to a Criticism of Tests Requiring Alternative Responses."  
Journal of Ed. Research, VI, 1922, 357-59
- Chapman, J. Crosby "Individual Injustice and Guessing in the True-False Examination"  
Journal of Applied Psychology, VI, 1922, 342-48
- Dewey, John "How We Think"  
D. C. Heath, Boston
- Gates, A. I. "The True-False Test as a Measure of Achievement in College Courses"  
Journal of Educational Psychology, XII, 1921, 276-287
- Hahn, H. H. "A Criticism of Tests requiring Alternative Responses"  
Journal of Educational Research, VI, 1922, 235-40
- Hotz, H. "Algebra Scales"  
Contribution to Education No. 90  
Teachers College, Columbia University
- Kelley, Truman Lee "Educational Guidance" An Experimental Study in the Analysis and Prediction of Ability of High School Pupils"  
Teachers College Contribution to Ed. No. 71, 1914, page 116.
- Knight, F. B. "Data on the True-False Test as a Device for College Examinations"  
Journal of Educational Psychology XIII, 1922, 75-80
- Laird, D. A. "A Comparison of the Essay and the Objective Types of Examinations"  
Journal of Educational Psychology, XIV 1923, 123-24
- McCall, Wm. A. "How to Measure in Education"  
The MacMillan Company, Chicago
- "How to Experiment in Education"  
The MacMillan Company, Chicago

Metzler, W. H. "Problems in the Experimental Pedagogy of Geometry"  
Journal of Educational Psychology 3:1912, 545-560

Minnick, J. H. "Geometry Tests" 1919  
University of Pennsylvania, Philadelphia

"A Scale for Measuring Pupils' Ability to Demonstrate Geometry Problems"  
The School Review, Feb. 1918, Vol. 27, 101-109

Monroe, W. S. "An Introduction to the Theory of Educational Measurements"  
Houghton Mifflin Co., 1922

"Written Examinations"  
Bulletin No. 17, 1923  
Bureau of Educational Research  
University of Illinois, Urbana

Odell, C. W. "Another Criticism of Tests Requiring Alternative Responses"  
Journal of Educational Research, VIII 1923, 326-30

Otis, Arthur S. "Statistical Method In Educational Measurement"  
The World Book Company

Remmers, H. H. "An Experimental Study of the Relative Difficulty of True-False, Multiple Choice, and Incomplete-Sentence Types of Examinations"  
Journal of Educational Psychology, XIV, 1923, 366-372

Rogers, Agnes L. "Test of Mathematical Ability" 1919,  
Bureau of Publications  
Teachers College, Columbia University

Ruch, G. M. "Improvement of the Written Examination"  
Scott Foreman & Company, Chicago, 1925.

"A Speed Factor in Mental Measurements" 1924  
Journal of Educational Research, Jan. 1924, 39-45

Ruch, G. M. and Stoddard, G. D. "Comparative Reliabilities of Five Types of Objective Examinations"  
Journal of Educational Psychology, Jan.-Feb. 1925.

- Rugg, Harold O. "Statistical Method Applied to Education"  
Houghton Mifflin, Chicago
- Sanford, Vera "An Achievement Test in Plane Geometry" 1923  
Revision of the Schorling Geometry Test  
The Lincoln School, Columbia University
- Starch, David "Starch-Hemenway Geometry Test" 1919  
University of Wisconsin, Madison
- Stockard, L. V. and Bell, J. Carlton "A Preliminary Study of the Measurement of  
Abilities in Geometry"  
Journal of Educational Psychology, Vol. 7,  
Dec. 1916
- Toops, H. A. "Trade Tests in Education"  
Teachers College, Columbia University  
Contribution to Education No. 115, 1921
- Touton, Frank C. "Solving Geometric Originals"  
Contribution to Education No. 146  
Teachers College, Columbia University
- West, P. V. "A Critical Study of the Right-Minus-Wrong  
Method"  
Journal of Educational Research, VIII 1-9  
1923
- Wood, Ben D. "Measurements in Higher Education"  
The World Book Company, 1923
- "Studies of Achievement Tests"  
Journal of Educational Psychology, XVII  
Jan. 1926, page 1; XVII Feb. 1926, page 125.
- Woody, Clifford "Arithmetic Scales"  
Contribution to Education No. 89  
Teachers College, Columbia University

(Experimental Use Only)

## FORM A

ACHIEVEMENT TEST IN PLANE  
GEOMETRY

By MAUDE McMINDES

Name..... Grade .....

Age.....years .....months. Boy or girl.....

Date..... School..... City.....

Number of months you studied geometry.....

What textbook did you use?.....

| TIME           | PART  | SCORE |
|----------------|-------|-------|
| 30 min.        | I     |       |
| 30 min.        | II    |       |
| 30 min.        | III   |       |
| 10 min.        | IV    |       |
|                | Total |       |
| Classification |       |       |

**GENERAL DIRECTIONS:** This examination consists of four parts and requires 100 minutes of actual working time. It is not expected that you will finish all of each part in the time allotted. First go through each list and answer those you are sure of. Do not depend on guessing. It does not pay. Your greatest asset will be to read the problem correctly and do as you are told to do. If you finish any part before "time" is called, spend the remainder of your time checking the work you have done. Do not break the seal for the next part until told to do so by the examiner. You will need an eraser, ruler, compass and several pencils. Do not provide any scratch paper. Blank pages are provided for all necessary figuring. Directions are given for each part. The examiner will read them with you so you will understand exactly what is wanted.

**INSTRUCTIONS FOR EXAMINER:** Pass out one copy to each student, instructing them not to break the seal until told to do so. Read the above General Directions to the student slowly and in a clear tone. Be sure that they thoroughly understand what is contained in the General Directions before breaking the seal. Each of the four parts of the test is also preceded by directions to be read by the examiner before the students begin that part. Have the sample questions answered aloud and marked by the pupils. Count the time for each test from the completion of the samples. No questions should be allowed after the test begins.

**NOTE:** It is not necessary that this test be given in a continuous working period of 100 minutes. The seals are so arranged that it can be given in two periods of 30 minutes each and one period of 40 minutes, thereby accommodating itself to the time schedule of class periods of various schools.

## PART I. TRUE—FALSE TEST.

Directions: If the statement is true, place a + sign on the dotted line before it. If the statement is false, place a 0 sign on the dotted line before it. Do not guess. Solve the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

Example:

- ..+.....1. There are 180 degrees in the angles of a triangle.  
 ....0.....2. Isosceles triangles are equilateral.
- 
- .....1. There are 45 degrees in one half of a right angle.  
 .....2. All right triangles are equal.  
 .....3. All operations of plane geometry are confined to a plane.  
 .....4. If a drawing is enlarged, the angles are enlarged in the same ratio.  
 .....5. If two parallels are cut by a transversal, the bisectors of the four interior angles form a rectangle.  
 .....6. If the sum of two angles equals 180 degrees, they are said to be complementary.  
 .....7. The converse of a correct definition is always true.  
 .....8. A square is a rectangle, therefore a rectangle is a square.  
 .....9. If the acute angles of a right triangle are 30 degrees and 60 degrees respectively, the shorter side is equal in length to one-half the hypotenuse.  
 .....10. The diagonals of a rhombus are equal.  
 .....11. If a central angle be doubled, its chord is also doubled.  
 .....12. The locus of all points equidistant from the vertices of a triangle is the intersection of the perpendicular bisectors of the sides.  
 .....13. A segment of a circle may also be a sector of the same circle.  
 .....14. If I divide the circumference of a circle whose diameter is 10 inches into four equal parts and the circumference of a circle whose diameter is 5 inches into four parts, the central angle of the first is double the central angle of the second.  
 .....15. If one angle of a quadrilateral is a right angle, all of the angles are right angles.  
 .....16. The converse of the following is true: "If two sides of a triangle are equal, the angles opposite them are equal."  
 .....17. The lines joining the middle points of the adjacent sides of any quadrilateral form a parallelogram.  
 .....18. The diagonals of a rectangle are perpendicular to each other.  
 .....19. A trapezoid has only one pair of sides equal and parallel.  
 .....20. The angle between two tangents to a circle is the supplement of the angle between the radii drawn to the points of tangency.  
 .....21. A circle can always be circumscribed about a quadrilateral whose opposite angles together equal 180 degrees.  
 .....22. The square of one side of a square equals half the product of its diagonals.  
 .....23. If two chords intersect in a circle the sum of the segments of the one equal the sum of the segments of the other.  
 .....24. A median of a triangle divides the triangle into two equal triangles.

(Turn to Page 4 and continue)

(Use this space for figuring)

- .....25. If two triangles have their sides respectively parallel, they are similar.
- .....26. Tangents drawn to a circle from a point outside are equal.
- .....27. The apothem of a regular polygon is the radius of the circumscribed circle.
- .....28. By doubling the number of sides of an inscribed polygon indefinitely, the difference between the circumference of the circle and the perimeter of the polygon may be made as small as desired.
- .....29. The lines joining the midpoints of the sides of a triangle form four congruent triangles.
- .....30. In any right triangle the perpendicular from the vertex of the right angle to the hypotenuse is the mean proportional between the sides of the right triangle.
- .....31. If two lines form equal adjacent angles, they are perpendicular to each other.
- .....32. If an inscribed angle and a central angle intercept the same arc in the same circle, they are equal.
- .....33. Only two circles can be drawn through two given points.
- .....34. The bisectors of the angles of a triangle meet in a point equidistant from the vertices.
- .....35. The area of a trapezoid equals the product of the median and altitude.
- .....36. If any number of equal angles are inscribed in an arc, their bisectors pass through a common point.
- .....37. The diagonals of parallelograms bisect each other.
- .....38. A decagon is a ten sided figure.
- .....39. If a polygon is equilateral, it is equiangular.
- .....40. If each of the equal sides of an isosceles triangle is greater than the third side, the vertex angle is greater than 60 degrees.
- .....41. The sum of the lines drawn from a point within a triangle to the vertices is greater than half the perimeter of the triangle.
- .....42. The diagonals of an isosceles trapezoid are equal.
- .....43. All rhombuses are similar.
- .....44. The bisector of the vertex angle of an isosceles triangle is perpendicular to the base.
- .....45. The locus of the midpoints of a system of equal chords is the diameter.
- .....46. The bisectors of the angles of a square form a square.
- .....47. Radii forming 60 degree angles at the ends of a chord form with the chord an equilateral triangle.
- .....48. Areas of similar figures are to each other as their corresponding sides.
- .....49. The greatest distance one can see from an airplane to the earth's surface is the mean proportional between the diameter of the earth and the height of the plane above the earth.
- .....50. Pattern makers use the carpenter's square to determine a semi-circle. If the right angle of the square touches the curve at all points while the sides rest on the ends of the arc, it is a semicircle.

(Turn to Page 6 and continue)

(Use this space for figuring)

- .....51. In a right triangle the sine of one of the acute angles equals cosine of the other acute angle.
- .....52. In ancient art if a rectangular picture frame bore this proportion it was considered artistic:  

$$\frac{\text{Half perimeter}}{\text{Length}} = \frac{\text{Length}}{\text{Width}}$$
- .....53. The ratio of the circumference to the diameter of a circle is constant for all circles.
- .....54. If the dimensions of a rectangle are doubled, its area is also doubled.
- .....55. The line joining the mid-points of two sides of a triangle is equal to one-fourth the other side.
- .....56. If a  $\frac{b}{d} = \frac{c}{d}$  then a  $\frac{d}{c} = \frac{b}{d}$ .
- .....57. The converse of this statement is true: "A square is a rectilinear having four equal sides."
- .....58. A yard of silk "cut on the bias" will not contain as much material as a yard cut at right angles to the edges.
- .....59. If two angles of a quadrilateral are supplementary, the other two are supplementary also.
- .....60. The medians of a triangle intersect in a point which is one-half the distance from the vertex to the midpoint of the opposite side.
- .....61. Two lines are crossed by a third line. The lines are parallel if the two interior angles on the same side of the transversal are  $1\frac{3}{5}$  right angles and  $36$  degrees respectively.
- .....62. Four equal angles complete the opening about a point on one side of a straight line. Each angle is  $90$  degrees.
- .....63. The altitudes to the legs of an isosceles triangle are equal.
- .....64. A piece of paper has been cut for a kite with its upper edges  $7$  inches and its lower edges  $16$  inches. The cross sticks forming the framework are perpendicular to each other.
- .....65. Regular pentagons can be used to fill the angular magnitude about a point without overlapping.
- .....66. As the number of sides of a polygon increases by  $1$ , the sum of its angles increases by  $2$  right angles.
- .....67. A pair of shears has the blades twice as long as the handles. The ends of the handles are always twice as far apart as the ends of the blades.
- .....68. Three regular hexagons are constructed on the sides of a right triangle. The largest equals the sum of the other two.
- .....69. The difference between two sides of a triangle is less than the third side.
- .....70. A base angle of an isosceles triangle is divided by a line so that it equals one-half the vertex angle. This line is perpendicular to the opposite leg.
- .....71. Two right triangles are congruent if the hypotenuse and a right angle of the one are equal to the hypotenuse and a right angle of the other.
- .....72. Through the end of the diameter two chords are drawn making with the diameter angles  $55$  degrees and  $40$  degrees respectively. The first chord is longer than the second.

(Turn to Page 8 and continue)

(Use this space for figuring)

- .....73. The sum of the squares of the four sides of a parallelogram equals the sum of the squares of the diagonals.
- .....74. The bisectors of two exterior angles of any triangle and the bisector of the non-adjacent interior angle concur.
- .....75. If two chords intersect within a circle and make equal angles with the radius drawn through the point of intersection, the chords are not necessarily equal.
- .....76. A central angle and a vertex angle of any regular polygon are always supplementary.
- .....77. Two regular polygons one having twice the number of sides of the other are circumscribed about the same circle. The one with the greater number of sides has the greater perimeter.
- .....78. In any circumscribed quadrilateral, the sum of two opposite sides equals the sum of the other two opposite sides.
- .....79. A common internal tangent to two circles bisects the line of centers.
- .....80. An inscribed trapezoid is not necessarily isosceles.
- .....81. Tangents drawn at the middle points of the arcs subtended by sides of a regular inscribed polygon form another polygon of the same number of sides.
- .....82. The converse of the following is sometimes false: "Polygons are similar, if they can be decomposed into triangles which are similar and similarly placed."
- .....83. The bisector of an angle of a triangle divides the opposite side into segments proportional to the adjacent sides.
- .....84. If lines be drawn from any vertex of a parallelogram to the mid-points of the opposite sides, they will divide the diagonal which they intersect into three equal parts.
- .....85. M is any point within the arallelogram ABCD. Lines are drawn from M to the four vertices. The sum of the areas of the triangles MAB and MCD is one-half the area of the parallelogram.
- .....86. If an equilateral triangle is inscribed in a circle, the distance of each side from the center is equal to half the radius of the circle.
- .....87. If two circles are externally tangent and a line intersecting the circles is drawn through the point of contact, diameters drawn from the points of intersection are perpendicular.
- .....88. With a ruler and compass a square can be constructed which has the same area as a given circle.
- .....89. The shortest and the longest line-segments that can be drawn to a circle from a point within the circle are the segments of the diameter through that point.
- .....90. Lines are drawn from a vertex of a triangle to the opposite side cutitng that side into three equal divisions. The lines are equal.

(Do not break the next seal until told to do so)

(Use this space for figuring)

**PART II. PROBLEMS.**

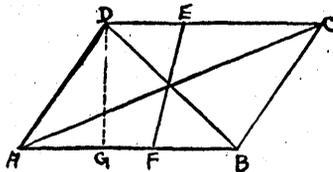
**DIRECTIONS:** Find the answers to these problems and write them on the dotted line to the left. Solve the easy ones first, then go back to the harder ones later. If it is necessary to extract the square root, carry to one decimal place. Use the opposite page for figuring.

**EXAMPLE:**

- ..40..1. Find the third angle of a triangle if two of the angles equal 50 degrees and 90 degrees respectively.

- .....1. Each angle of a square equals how many degrees?  
 .....2. What is the complement of a 40 degree angle?  
 .....3. The bases of a trapezoid are 10 inches and 7 inches respectively and the altitude is 8 inches. Find the area.  
 .....4. The diagonals of a rhombus are 10 feet and 12 feet respectively. What is its area?  
 .....5. If the scale of a certain drawing is  $\frac{1}{4}'' : 1'$ , how many feet does a 6 inch line represent?  
 .....6. A stairway rising at an angle of 30 degrees leads from one floor to another 12 feet above. Find the length of the railing.  
 .....7. One of interior angles of a regular polygon is 140 degrees. How many sides has the polygon?  
 .....8. If a wheel makes 10 revolutions per minute, through how many degrees does it turn in one second?  
 .....9. One of the angles of a triangle equals 70 degrees. Its adjacent exterior angle equals how many degrees?  
 .....10. A gate post 4 feet high casts a shadow 18 feet long at the same time a house casts a shadow 144 feet long. How tall is the house?  
 .....11. The perimeter of a triangle is 30 inches and the sides are in the ratio 5:7:9. What is the length of the longest side?  
 .....12. A rectangular garden 48 feet long by 24 feet wide has a 5 foot cement walk around it. How many square feet of cement in the walk?  
 .....13. An isosceles triangle has sides 30 inches and an area of 150 square inches. A line drawn parallel to the base cuts off a triangle whose area is 60 square inches. Find one of the legs of the smaller triangle.  
 .....14. What is the length of the side of a square equal in area to a triangle whose base is 24 and whose altitude is 12 inches?

.....15.



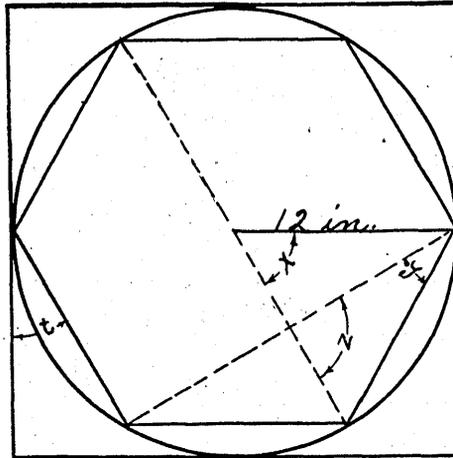
ABCD is a parallelogram whose diagonals intersect at O. EF is any line drawn through O. DG is equal to 20 inches and AB to 40 inches. How many square inches in FBCE?

- .....16. The arch above a door 8 feet wide has a height of 2 ft. What is the radius of the circle of which the arch is an arc?  
 .....17. How many rods of fencing necessary to enclose a square field of 10 acres?  
 .....18. Two sides of a triangle are 16 ft. and 21 ft. A line parallel to the third side cuts the 16 ft. side 5 ft. from the vertex. How many feet in the segment joining the vertex on the 21 ft. side?

(Turn to Page 12 and continue)

(Use this space for figuring)

- .....19. Determine the angle formed by the bisectors of the base angles of a triangle which are 56 degrees and 36 degrees respectively.
- .....20. If an angle of a triangle is unchanged but each of the two including sides is doubled, the area of the original triangle is what part of the area of the new triangle?



You are given a circle with a radius of 12 inches. In it is an inscribed hexagon and about it is a circumscribed square. Answer the following on the above diagram:

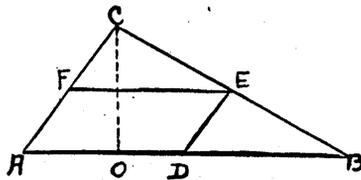
- .....21. How many inches in perimeter of square in above figure?
- .....22. How many inches in perimeter of hexagon in above figure?
- .....23. How many inches in circumference of circle in above figure?
- .....24. How many square inches in area of square in above figure?
- .....25. How many square inches in area of hexagon in above figure?
- .....26. How many square inches in area of circle in above figure?
- .....27. How many degrees in angle x in above figure?
- .....28. How many degrees in angle y in above figure?
- .....29. How many degrees in angle z in above figure?
- .....30. How many degrees in angle t in above figure?
- .....31. The area of a regular hexagon is 36 square inches. The diagonals joining the alternate vertices are drawn to form a second regular hexagon. Required the area of the newly formed hexagon.
- .....32. In order to find the approximate diameter of a porch column, a point C 3 ft. from the circumference was selected. A tangent from this point to the column measured 5 ft. Required the diameter of the column.
- .....33. A piece of cloth 18 inches wide is to be cut on the bias at an angle of 45 degrees. How long is the bias cut?
- .....34. How many degrees in a radian?
- .....35. The square on the base of an equilateral triangle contains 1600 sq. ft. What is the area of a square built on the altitude of the same triangle?

(Turn to Page 14 and Continue)

(Use this space for figuring)

- .....36. How many people can be seated at a round table 42 inches in diameter after it has been extended 2 ft., allowing 20 inches to one person?
- .....37. A cow is tied at the end of a 100 ft. rope which is attached to the corner of a barn 50 ft. square. Over how many square feet can the cow graze?
- .....38. If the area of a circumscribed square is 400 square inches, what is the area of an inscribed square in the same circle?
- .....39. The sides of a triangle are 3, 4 and 6 inches respectively. Find the longest side of a similar triangle whose area is 9 times as great.

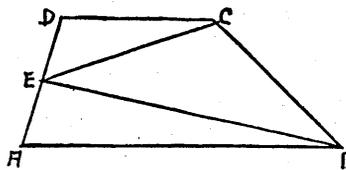
.....40.



In the triangle ABC, through E the midpoint of CB parallels to the side of AB and AC are drawn. The side AB is 30 in. and the altitude CO is 10 in. Required the area of ADEF.

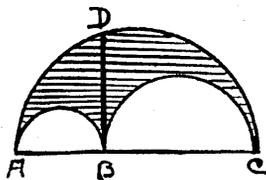
- .....41. A room is 20 by 12 by 10 ft. high. How far is it from one corner of the floor direct through the room to the farthest opposite corner of the ceiling?

.....42.



ABCD is a trapezoid with E the midpoint of AD. The perpendicular distance between the parallel bases is 10 inches. The bases are 20 and 25 ft. Required the area of the triangle EBC.

.....43.



B is any point on the line AC. Semi-circles are drawn with AB, BC, AC as diameters. BD is perpendicular to AC and is 7 inches. What is the area of the shaded surface?

- .....44. In triangle ABC, AB equals 5 inches, AC equals 6 inches, and BC equals 7 inches. Find the shorter segment into which the bisector of angles C divides the side AB.
- .....45. Find the area of a parallelogram whose sides are 8 and 12 inches respectively and whose diagonal is 15 inches.

(Do not break the next seal until told to do so)

(Use this space for figuring)

## PART III. LOGICAL SELECTION.

GENERAL DIRECTIONS: Select the one word or group of words that makes the statement true. Write the number of the word or group of words on the dotted line at the left of the statement. Solve the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

## EXAMPLE:

.....1. A figure bounded by four straight lines is called a 1 (triangle), 2 (decagon), 3 (pentagon), 4 (hexagon), 5 (quadrilateral).

- .....1. Vertical angles are always 1 (complementary), 2 supplementary), 3 (acute), 4 (obtuse), 5 (equal).
- .....2. Concentric circles have the same 1 (radii), 2 (circumference), 3 (centers), 4 (areas).
- .....3. The diagonals of a 1 (rectangle), 2 (parallelogram), 3 (trapezoid), 4 (square), 5 (rhombus) are equal, bisect the angles, bisect each other, and are perpendicular to each other.
- .....4. If your watch registers 8 o'clock at the same time President Coolidge's watch registers 10 o'clock, he is 1 (15), 2 (30), 3 (35), 4 (60), 5 (120) degrees east of you.
- .....5. Two circles have at most 1 (no), 2 (one), 3 (two), 4 (three), 5 (unlimited number of) points in common.
- .....6. The locus of all points 4 inches from each of two given points which are 6 inches apart is 1 (a circle), 2 (one point), 3 (two points), 4 (a line parallel to the line joining the points), 5 (the perpendicular bisector of the line joining the two points).
- .....7. The sum of the exterior angles of a regular octagon is 1 (180), 2 (360), 3 (1080), 4 (1440), 5 (2880) degrees.
- .....8. The chord of a 180 degree angle is 1 (equal to), 2 (double), 3 (three times), 4 (four times) the chord of a 60 degree central angle.
- .....9. The diagonals of a parallelogram divide it into four 1 (equal), 2 (similar), 3 (congruent), 4 (isosceles), 5 (right) triangles.
- .....10. The bisectors of the angles, the medians and the altitudes of a triangle coincide in 1 (right), 2 (scalene), 3 (isosceles), 4 (equilateral), 5 (acute) triangles.
- .....11. Three angles of one triangle equal to three angles of another make the triangles 1 (equal), 2 (acute), 3 (similar), 4 (congruent), 5 (equilateral).
- .....12. If the base of the first rectangle is 3 times that of the second rectangle but the altitude of the first is  $\frac{1}{3}$  that of the second, the ratio of their areas is 1 (3:1), 2 (1:3), 3 ( $\frac{1}{3}$ :3), 4 ( $\frac{1}{3}$ :1), 5 (3:3).
- .....13. Tangents are drawn at the ends of a chord which subtends an arc of 120 degrees. A 1 (right), 2 (equilateral), 3 (obuse), 4 (scalene) triangle is formed.
- .....14. On a warship, a canon, which shoots ten miles, brings into danger all persons within a radius of 1 (5), 2 (10), 3 (20), 4 ( $63\frac{6}{7}$ ), 5 ( $314\frac{2}{7}$ ) miles.

(Turn to Page 18 and continue)

(Use this space for figuring)

- .....15. The altitudes of an obtuse triangle meet in a point which is 1 (inside), 2 (outside), 3 (on one of the vertices of), 4 (on one of the sides of) the triangle.
- .....16. When the sun's rays strike the earth at an angle of 48 degrees, the length of the tree's shadow is 1 (shorter than), 2 (longer than), 3 (equal to), 4 (exactly half), 5 (exactly double) the height of the tree.
- .....17. The greatest number of common tangents two circles may have is 1 (one), 2 (two), 3 (three), 4 (four), 5 (five).
- .....18. Line AB and CD bisect each other at P. CA is 1 (equal), 2 (parallel), 3 (perpendicular), 4 (equal and parallel), 5 (equal and perpendicular) to BD.
- .....19. X is the midpoint of the line BC. The length of perpendiculars from B and C to any line through X are 1 (always equal), 2 (never equal), 3 (sometimes equal), 4 (dependent on length of BC), 5 (dependent on angle the line drawn through X makes with the line BC).
- .....20. Angle A of the triangle ABC is greater than angle B. Their bisectors meet at point M. BM as compared to AM is 1 (longer), 2 (equal to), 3 (shorter than), 4 (dependent upon the angles of the triangle ABC), 5 (dependent upon the sides of the triangle ABC).
- .....21. If the median equals one-half the side it bisects, the triangle is 1 (isosceles), 2 (equilateral), 3 (scalene), 4 (obtuse), 5 (right).
- .....22. The bisectors of the exterior angles of a parallelogram form 1 (an octagon), 2 (an isosceles trapezoid), 3 (a rhombus), 4 (a square), 5 (a rectangle).
- .....23. The altitude to one of the sides of an acute triangle falls 1 (outside), 2 (inside), 3 (along one of the sides), 4 (either inside or outside).
- .....24. In parallelogram ABCD, BA is produced to M and DC to N making AM equal to CN. BN is 1 (equal), 2 (parallel), 3 (perpendicular), 4 (both equal and parallel), 5 (both equal and perpendicular) to DM.
- .....25. In two isosceles triangles the sides of the one equal the sides of the other but the altitude of the first is equal to half the base of the second. The area of the first as compared to the area of the second is 1 (half), 2 (double), 3 (equal to), 4 (dependent on the included angle between the equal sides), 5 (dependent on the length of the equal sides).
- .....26. A farmer wants to build a picket fence around a lot. The two sides are the same distance from corner to corner. One side is over level ground and the other side goes over a steep hill. He wants the pickets two inches apart and to stand vertical or plumb. The number of pickets needed for the side over the hill as compared with the side on level ground is 1 (the same), 2 (more), 3 (less), 4 (depends on the slope of the hill).
- .....27. Two roads intersect. There are 1 (one), 2 (two), 3 (four), 4 (eight), 5 (indefinite number of) points equidistant from the two roads and ten miles from the intersection of the roads.

(Turn to Page 20 and continue)

(Use this space for figuring)

- .....28. My neighbor and I each built a pasture fence of the same material and containing the same area, ten acres. I built my fence in the form of a rectangle, and my neighbor built his fence in the form of a square. My expense was 1 (less), 2 (equal to), 3 (more), 4 (less, more or equal depending on conditions).
- .....29. In any 1 (acute), 2 (obtuse), 3 (right), 4 (equilateral), 5 (isosceles) triangle, the bisector of any angle forms two congruent triangles.
- .....30. A circle may be inscribed in any 1 (triangle), 2 (quadrilateral), 3 (pentagon), 4 (hexagon), 5 (decagon).
- .....31. If the angle at the center of a regular polygon is 40 degrees, the polygon has 1 (four), 2 (six), 3 (eight), 4 (nine), 5 (ten) sides.
- .....32. The locus of the vertices of right angle triangles erected on a common hypotenuse is 1 (a point), 2 (two points), 3 (a line parallel to the hypotenuse), 4 (two lines parallel to the hypotenuse), 5 (a circle).
- .....33. A perpendicular erected at the midpoint of one of the sides of an equilateral polygon and extended to the center of the polygon is a 1 (tangent), 2 (chord), 3 (secant), 4 (diagonal), 5 (apothem).
- .....34. If through any point in the bisector of an angle a line is drawn parallel to either of the sides of the angle, the triangle thus formed is 1 (isosceles), 2 (equilateral), 3 (obtuse), 4 (right).
- .....35. Any angle inscribed in a segment smaller than a semicircle is 1 (acute), 2 (obtuse), 3 (right).
- .....36. In an isosceles trapezoid, the triangles formed by the two diagonals and the bases are 1 (similar), 2 (equal), 3 (congruent), 4 (equilateral), 5 (right).
- .....37. The radius of the circle inscribed in an equilateral triangle is equal to 1 (one-third), 2 (one-half), 3 (two-thirds), 4 (one-fourth), 5 (three-fourths) the altitude of the triangle.
- .....38. ABCD is a parallelogram. P is any point on the side CD. AP produced, meets BC produced at Q. The figure contains three 1 (equal), 2 (equilateral), 3 (isosceles), 4 (congruent), 5 (similar) triangles.
- .....39. In triangle ABC, medians AE and CD intersect at point O. Triangle AOC is equal in area to 1 (COE), 2 (AOD), 3 (DBEO), 4 (none of the figures).
- .....40. CA and CB the equal sides of an isosceles triangle ABC are produced through A and B to points D and E respectively so that AD equals BE. The triangles ABD and ABE are 1 (equilateral), 2 (isosceles), 3 (right), 4 (equal).
- .....41. The locus of the vertices of all triangles having a common base and the same area is 1 (a point), 2 (two points), 3 (a line parallel to the base), 4 (two lines one on either side and parallel to the base).
- .....42. Of all triangles that have the same base and the same altitude the 1 (right), 2 (acute), 3 (isosceles), 4 (obtuse) has the minimum perimeter.

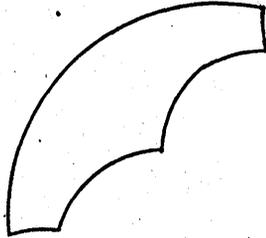
(Do not break the next seal until told to do so.)

(Use this space for figuring)

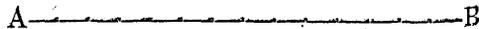
**PART IV. CONSTRUCTIONS.**

**DIRECTIONS:** Construct using ruler and compass. Make all arcs, lines, etc. distinctly visible for the examiner.

1. Complete the circumference.

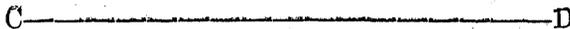


2. Erect a perpendicular at the end of the line AB. Do not extend the line.



3. Draw a line through a point P and parallel to CD.

P

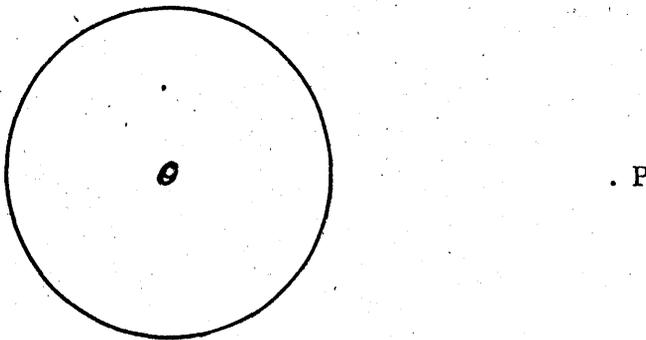


(Continue on opposite page.)

4. Enlarge the line segment MN in the ratio of 3:5.



5. Construct a tangent from point P to the Circle O.



— END —

(Experimental Use Only)

## FORM B

# ACHIEVEMENT TEST IN PLANE GEOMETRY

By MAUDE McMINDES

Name..... Grade .....

Age.....years .....months. Boy or girl.....

Date..... School..... City.....

Number of months you studied geometry.....

What textbook did you use?.....

| TIME           | PART  | SCORE |
|----------------|-------|-------|
| 30 min.        | I     |       |
| 30 min.        | II    |       |
| 30 min.        | III   |       |
| 10 min.        | IV    |       |
|                | Total |       |
| Classification |       |       |

**GENERAL DIRECTIONS:** This examination consists of four parts and requires 100 minutes of actual working time. It is not expected that you will finish all of each part in the time allotted. First go through each list and answer those you are sure of. Do not depend on guessing. It does not pay. Your greatest asset will be to read the problem correctly and do as you are told to do. If you finish any part before "time" is called, spend the remainder of your time checking the work you have done. Do not break the seal for the next part until told to do so by the examiner. You will need an eraser, ruler, compass and several pencils. Do not provide any scratch paper. Blank pages are provided for all necessary figuring. Directions are given for each part. The examiner will read them with you so you will understand exactly what is wanted.

**INSTRUCTIONS FOR EXAMINER:** Pass out one copy to each student, instructing them not to break the seal until told to do so. Read the above General Directions to the student slowly and in a clear tone. Be sure that they thoroughly understand what is contained in the General Directions before breaking the seal. Each of the four parts of the test is also preceded by directions to be read by the examiner before the students begin that part. Have the sample questions answered aloud and marked by the pupils. Count the time for each test from the completion of the samples. No questions should be allowed after the test begins.

**NOTE:** It is not necessary that this test be given in a continuous working period of 100 minutes. The seals are so arranged that it can be given in two periods of 30 minutes each and one period of 40 minutes, thereby accommodating itself to the time schedule of class periods of various schools.

## PART I. TRUE—FALSE TEST.

**DIRECTIONS:** If the statement is true, place a + sign on the dotted line before it. If the statement is false, place a 0 sign on the dotted line before it. Do not guess. Solve the easy ones first then go back to the harder ones later. Use the opposite page for figuring.

**EXAMPLE:**

- ..+.....1. There are 90 degrees in a right angle.  
 ....0....2. Two parallelograms are equal if the four sides of the one equal the four sides of the other.

- .....1. There are 60 degrees in each angle of an equilateral triangle.  
 .....2. The supplement of an obtuse angle equals the angle.  
 .....3. A right triangle can be isosceles.  
 .....4. A plane is a surface such that the line joining any two points within it lies wholly in the surface.  
 .....5. The converse of any theorem can be accepted without proof.  
 .....6. A rectangle is a parallelogram, therefore a parallelogram is a rectangle.  
 .....7. The diagonals of a rhombus intersect each other at right angles.  
 .....8. If a chord is lengthened, the central angle subtended is increased in the same ratio.  
 .....9. The locus of all points equidistant from the sides of a triangle is the intersection of the perpendicular bisectors of the sides of the triangle.  
 .....10. An angle of 360 degrees is called a perigon.  
 .....11. If one side of a right triangle is half the hypotenuse the smaller acute angle contains 30 degrees.  
 .....12. If the sides of a parallelogram are equal, the figure is a square.  
 .....13. The radius of a regular polygon bisects the angle to whose vertex it is drawn.  
 .....14. A median of a triangle divides the triangle into two equal triangles.  
 .....15. A quadrilateral with one pair of sides equal and parallel is a trapezoid.  
 .....16. The sum of the three altitudes of a triangle is less than the perimeter.  
 .....17. If one side of a triangle is produced in both directions, the sum of the exterior angles of the triangle adjacent to this line is greater than two right angles.  
 .....18. The lines joining the midpoints of the sides of a triangle form four equilateral triangles.  
 .....19. An inscribed angle intercepting the same arc as a central angle is double the central angle in magnitude.  
 .....20. If one square is double another square in area, the side of the first square is twice that of the second square.  
 .....21. The bisectors of the angles of a rectangle form a square.  
 .....22. If the diagonals of a parallelogram are equal, the figure is a rectangle.  
 .....23. The angle made by the bisectors of the base angles of an isosceles triangle is equal to an exterior angle at the base.

(Turn to Page 4 and continue)

---

(Use this space for figuring)

- .....24. If the angles made by the non-parallel sides of a trapezoid with either of the parallel sides are equal, the trapezoid is isosceles.
- .....25. In a right triangle the middle point of the hypotenuse is equidistant from the three vertices.
- .....26. The cosine of a 40 degree angle of a right triangle equals the sine of the 50 degree angle of the same triangle.
- .....27. Any side of a polygon is less than the sum of all the other sides.
- .....28. If a diagonal of a quadrilateral bisects two of its angles, it is perpendicular to the other diagonal.
- .....29. The parallelogram formed by joining the middle points of the adjacent sides of any quadrilateral is equal in area to one-half the quadrilateral.
- .....30. The area of a trapezoid is equal to half the product of one of its parallel sides and the distance to it from the middle point of the opposite side.
- .....31. The area of a triangle equals the product of its perimeter and the radius of the inscribed circle.
- .....32. The area of a sector of a circle equals one-half the product of its radius and its arc.
- .....33. The bisectors of the angles of a parallelogram are concurrent.
- .....34. The converse of the following is true, "If a quadrilateral is a square, its diagonals intersect at right angles."
- .....35. The lines joining the mid-points of the opposite sides of a quadrilateral bisect each other.
- .....36. A rectangle and an oblique parallelogram have the same base and equal altitudes. The oblique parallelogram has the greater perimeter.
- .....37. If one side of a triangle is divided into two parts by a perpendicular from the opposite vertex, each part of that side is less than the adjacent side of the triangle.
- .....38. If two circles are unequal, equal chords in each would subtend equal arcs in length.
- .....39. If a diameter bisects an arc, it bisects the chord of the arc at right angles.
- .....40. If the perpendiculars from the center upon two chords in the same circle are equal, the chords are equal.
- .....41. Two points, each equidistant from the ends of a chord, determine the diameter of the circle.
- .....42. Three circles pass through two points. Their diameters bisecting the chord connecting these two points form a triangle.
- .....43. Tangents from the same point to two concentric circles are equal.
- .....44. If a chord bisects an inscribed angle, it bisects the intercepted arc.
- .....45. Through the vertices of a quadrilateral straight lines are drawn parallel to the diagonals. The newly formed quadrilateral is twice the size of the original quadrilateral.
- .....46. The diagonals of a regular pentagon are equal.
- .....47. If the angles adjacent to the longer of two parallel sides of a trapezoid are equal, the non-parallel sides are equal.

(Turn to Page 6 and continue)

---

(Use this space for figuring.)

- .....48. The circumference of a circle is  $3\frac{1}{7}$  times its radius.
- .....49. T is any point on AB of the triangle ABC and S is the mid-point of AT, V the mid-point of CT, U the mid-point of AC, then TSUV is a parallelogram.
- .....50. If two lines intersect, their sum is greater than the sum of either pair of joins of the ends of the lines.
- .....51. In the quadrilateral ABCD. AD is the longest side and BC the shortest side. Angle B is smaller than angle D.
- .....52. If two chords of a circle bisect each other they pass through the center.
- .....53. The line of centers of two internally tangent circles is equal to the sum of the two radii.
- .....54. The radius of a circle circumscribed about a right triangle is equal to half the hypotenuse.
- .....55. From a point P outside a circle whose center is O, secants are drawn. The locus of the mid-points of the chords so formed is the arc of a circle.
- .....56. If the word "non-parallel" is omitted from the following theorem, it is false. "If two non-parallel lines are cut by three or more parallels, the corresponding segments are proportional.
- .....57. The corresponding sides of rectangles are proportional.
- .....58. Two triangles are similar if their sides are respectively perpendicular to each other.
- .....59. A triangle may be constructed from any three of its parts.
- .....60. If two triangles have an angle of the one supplementary to an angle of the other, they are to each other as the product of the sides including the angle of the first is to the product of the sides including the angle of the second.
- .....61. The projection of a line segment may be greater than, less than, or equal to the line segment itself.
- .....62. The sum of the perpendiculars from any point within an equilateral triangle to the sides is equal to the altitude of the triangle.
- .....63. The angle at the center of a regular polygon is the supplement of an interior vertex angle.
- .....64. Two right triangles are congruent if the hypotenuse and a side of one are equal to the hypotenuse and side of the other.
- .....65. If a polygon has "N" vertices, it has "N" sides.
- .....66. If unequals are subtracted from equals, the remainders are unequal in the same order.
- .....67. The difference between the diagonals of a quadrilateral is less than the sum of either pair of opposite sides.
- .....68. The lines joining the mid-points of the adjacent sides of an isosceles trapezoid form a rectangle.
- .....69. The perimeter of any regular circumscribed polygon approaches the circumference of the circle as a limit as the number of sides is indefinitely increased.
- .....70. If two angles of a quadrilateral are right angles, all the angles are right angles.
- .....71. One of the equal sides of an isosceles triangle is sometimes less than half the base.

(Turn to Page 8 and continue)

(Use this space for figuring.)

- .....72. If any number of equal angles are inscribed in an arc, their bisectors pass through a common point.
- .....73. Two plots of ground, one a square and one a circle, each contain the same area. The circle has the greater perimeter.
- .....74. If lines be drawn from any vertex of a parallelogram to the mid-points of the opposite sides, they will divide the diagonals which they intersect into three equal parts.
- .....75. A diameter is a chord, forms a sector, forms a segment, forms a semicircle and is a secant in a circle.
- .....76. Tangents to a circle from an outside point are perpendicular to the chord joining the points of contact.
- .....77. If two polygons are mutually equiangular they are similar.
- .....78. There are twice as many exterior angles to a triangle as interior angles.
- .....79. The line of centers of two intersecting circles is the perpendicular bisector of their common chord.
- .....80. The sums of the squares of the diagonals of a rhombus equals the sum of the squares of the four sides.
- .....81. An angle of a triangle is either acute, right or obtuse according as the square of the opposite side is less than, equal to, greater than the sum of the squares of the other two sides.
- .....82. Two parallelograms are congruent if they have two sides and an angle of the one equal to two sides and an angle of the other.
- .....83. A man is planning a house. The rectangular plan is 20x30 feet, making the perimeter of the house 100 feet. A second man has planned a square house with a perimeter of 100 feet. The first man has the greater floor area.
- .....84. A segment is divided by a given point into extreme and mean ratio when one part is the mean proportional between the whole segment and the other part.
- .....85. The opposite sides of a regular octagon are parallel.
- .....86. If the diagonal of any quadrilateral bisects two of its angles, it is perpendicular to the other diagonal and bisects it.
- .....87. Rectilinear figures are bounded by straight lines intersecting at right angles.
- .....88. If two triangles are similar, medians drawn from corresponding vertices are in the same ratio as the corresponding sides.
- .....89. If two secants are drawn to a circle from an external point, the sum of one secant and its external segment is equal to the sum of the other secant and its external segment.
- .....90. Two points are symmetrical with respect to a straight line as an axis if the straight line joining the two points is bisected at right angles by the axis.

(Do not break the next seal until told to do so.)

---

• (Use this space for figuring)

## PART II. PROBLEMS.

**DIRECTIONS:** Find the answers to these problems and write them on the dotted line to the left. Solve the easy ones first, then go back to the harder ones later. If it is necessary to extract the square root, carry to one decimal place. Use the opposite page for figuring.

**EXAMPLE:**

- .....20.....1. One of the acute angles of a right triangle is 70 degrees. How large is the other acute angle?

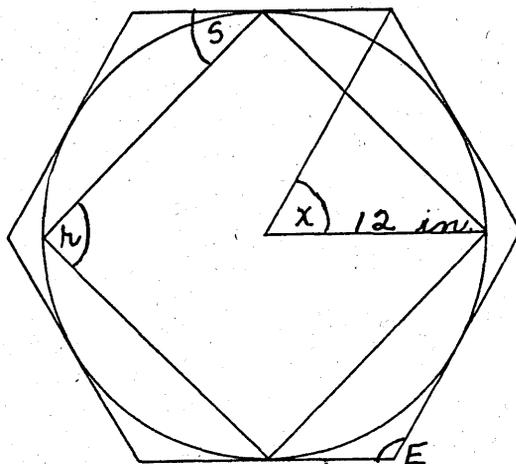
- 
- .....1. How many degrees in a straight angle?
- .....2. The base of a right triangle is 36 inches and its altitude is 20 inches. Determine the area.
- .....3. One of the diagonals of a square is 12 inches. What is its area?
- .....4. One of the interior angles of a regular polygon is 160 degrees. How many sides has the polygon?
- .....5. Determine the number of minutes necessary for the hour hand of a clock to turn through 36 degrees.
- .....6. The angles of a quadrilateral are in the ratio of 1:2:3:4. Determine the size of the largest angle.
- .....7. A 30 ft. ladder is leaning against a building and making a 60 degree angle with the ground. How far is the foot of the ladder from the building?
- .....8. An arc of a circle containing 24 degrees is 2 feet long. Find the circumference of the circle.
- .....9. A wheel stands in water which reaches halfway to the center of the hub. How many degrees are there in the arc bounding the submerged portion?
- .....10. A line is 10 inches long and makes an angle of 45 degrees with a second line. Find the length of the projection of the first line on the second.
- .....11. A man on top of a mountain one mile high sees a ship just coming into view? How far is he from the ship? (Radius of Earth=4000 miles.)
- .....12. The perimeter of an inscribed equilateral triangle is 28 inches. What is the perimeter of a circumscribed equilateral triangle of the same circle?
- .....13. The base of a right triangle is 12 ft. and the median on the hypotenuse is  $7\frac{1}{2}$  ft. Find the area.
- .....14. A chord 18 inches long lies 10 inches from the center of the circle. Find the radius.
- .....15. The radius of a circle is 12 inches. Find the radius of a concentric circle dividing the given circle into two equal areas.
- .....16. How many degrees in one of the angles of a five-pointed star?
- .....17. The sides of a triangle are 8, 10, and 12 inches. Find the short segment into which the 12 in. side is divided by the bisector of the interior angle at the opposite vertex.
- .....18. The diameter of the smaller of two concentric circles is 10 inches. A tangent of the smaller which is a chord of the larger is 8 in. long. What is the diameter of the larger circle?

(Turn to Page 12 and continue)

---

(Use this space for figuring.)

- .....19. The area of a trapezoid is 240 sq. ft., the altitude is 8 ft. and one base is 20 ft. Find the other base.
- .....20. What is the area of the rectangle formed by joining the mid-points of the adjacent sides of a rhombus whose diagonals are 30 and 40 inches respectively.
- .....21. The area of a triangle is 64 sq. in. Lines parallel to the base divide one side into four equal segments. Find the area of the triangular part into which the triangle is divided.
- .....22. Given: A parallelogram 24"x36". From one diagonal a line is drawn cutting the 36 in. side 12 in. from the opposite vertex and the 24 in. side 8 in. from the same vertex, thereby forming another quadrilateral. Determine its area.



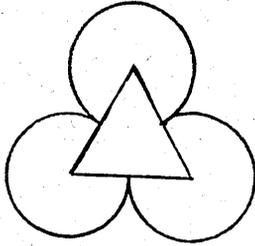
You are given a circle with a radius of 12 inches. In it is inscribed a square and about it is circumscribed a regular hexagon.

- .....23. What is the perimeter of the square of the above figure?
- .....24. What is the perimeter of the hexagon in the above figure?
- .....25. What is the circumference of the circle in the above figure?
- .....26. What is the area of the square in the above figure?
- .....27. What is the area of the hexagon in the above figure?
- .....28. What is the area of the circle in the above figure?
- .....29. How many degrees in angle X in the above figure?
- .....30. How many degrees in angle E in the above figure?
- .....31. How many degrees in angle S in the above figure?
- .....32. How many degrees in angle r in the above figure?
- .....33. The area of a circumscribed square is 2500 sq. in. What is the area of an inscribed square in the same circle?
- .....34. A piece of silk 27 inches wide is folded "on the bias". How long is the fold?
- .....35. The centers of two pulley wheels are 24 inches apart. The radii are respectively 9 inches and 21 inches. What is the length of the belt around the two pulleys?

(Turn to Page 14 and Continue)

(Use this space for figuring)

.....36.



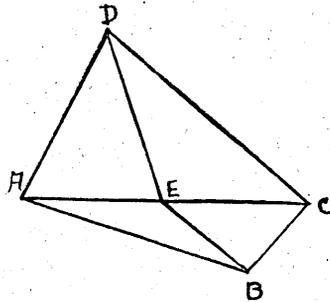
A trefoil is constructed by drawing the arcs of circles with centers at the vertices of an equilateral triangle and radii equal to one-half the side of the triangle. If the side of the triangle is 14 in. what is the perimeter of the trefoil?

.....37. What is the area of the above trefoil?

.....38. What is the inner diagonal of a cube whose edge is 6 in.?

.....39. Find the area of a triangle whose sides are 5, 6, and 7 inches respectively.

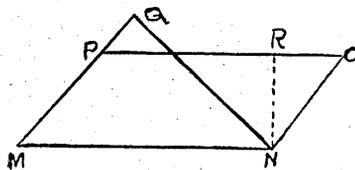
.....40.



Given: Quadrilateral ABCD with E the mid-point of AC. The area of the given quadrilateral is 400 sq. in. Determine the area of DEBC.

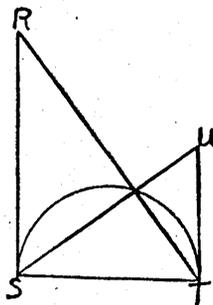
.....41. A cow is tied to a 50 ft. rope which is tied to the corner of a lot 25 ft. by 60 ft. Over how many sq. ft. outside the fence that surrounds the lot can the cow graze?

.....42.



Given  $NR \perp$  to  $PO$  and  $NQ \perp$  to  $MP$ .  $MN$  is parallel to  $PO$  and  $NO$  is parallel to  $MP$ .  $MN$  equals 40;  $MP$  equals 20;  $NR$  equals 15. Required  $QN$ .

.....43.



Given:  $RS$  equals 36 in.  $TU$  equals 25 in. Required: Diameter of semicircle.

(Do not break the next seal until told to do so.)

---

(Use this space for figuring)

### PART III. LOGICAL SELECTION.

**GENERAL DIRECTIONS:** Select the one word or group of words that makes the statement true. Write the number of the word or group of words on the dotted line at the left of the statement. Answer the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

**EXAMPLE:**

- ....5....1. A triangle containing a ninety degree angle is called 1 (an obtuse), 2 (an acute), 3 (an isosceles), 4 (an equilateral), 5 (a right) triangle.

- 
- .....1. If the sides of a triangle are all equal, the triangle is 1 (obtuse), 2 (right), 3 (scalene), 4 (isosceles), 5 (equilateral).
- .....2. The line drawn from any vertex to the midpoint of the opposite side of a triangle is 1 (bisector of the angle), 2 (bisector of the side), 3 (median), 4 (altitude from vertex to opposite side).
- .....3. There are 1 (one), 2 (two), 3 (three), 4 (many), 5 (no) points in one of the equal sides of an isosceles triangle equally distant from the extremities of the base.
- .....4. I am given a line equal to the perimeter of a rhombus. The number of rhombuses I can construct with this line equal to the perimeter is 1 (one), 2 (two), 3 (four), 4 (unlimited).
- .....5. A man walks across a rectangular garden so that he remains equidistant from the east and the south sides of the garden. His path is 1 (perpendicular to east side), 2 (perpendicular to south side), 3 (parallel to east side), 4 (parallel to south side), 5 (bisector of angle between the east and south sides).
- .....6. The degrees in a radian most nearly equal 1 (45), 2 (60), 3 (75), 4 (90), 5 (180) degrees.
- .....7. If from two opposite vertices of any parallelogram line segments are drawn to the middle points of the sides, the parallelogram thus formed is equal to 1 (one-third), 2 (one-half), 3 (two-thirds), 4 (three-fourths) of the given parallelogram.
- .....8. The triangle ABC and ABD have a common base AB and the line CD is parallel to AB. The triangles are 1 (similar), 2 (equivalent), 3 (congruent), 4 (right), 5 (isosceles).
- .....9. Two triangles are 1 (congruent), 2 (equilateral), 3 (similar), 4 (equal) if two sides of the one are equal respectively to two sides of the other and the included angles are supplementary.
- .....10. The midpoints of two sides of a triangle are joined to any point in the third side. The area of the quadrilateral thus formed is 1 (one-third), 2 (one-fourth), 3 (one-half), 4 (two-thirds), 5 (three-fourths) the area of the triangle.
- .....11. There are 1 (one), 2 (two), 3 (three), 4 (four), 5 (indefinite number of) solutions possible for the following: On a given base construct a parallelogram equivalent to a given square:

(Turn to Page 18 and continue)

(Use this space for figuring)

- .....12. If each side of an equilateral triangle is divided into three equal parts and the adjacent points connected, a hexagon is formed whose area is 1 (half), 2 (equal), 3 (two-thirds), 4 (three-fourths), 5 (six times) as great as the original triangle.
- .....13. Every line parallel to the bases of a trapezoid and terminating in the non-parallel sides, but not passing through the intersection of the diagonals is divided by the diagonals into three segments 1 (none of which are equal), 2 (two of which are equal), 3 (all are equal), 4 (equality dependent on the trapezoid).
- .....14. Two angles having a common side and a common vertex are 1 (acute), 2 (obtuse), 3 (equal), 4 (adjacent), 5 (vertical).
- .....15. If two tangents drawn from a point to a circle form an angle of 1 (30), 2 (45), 3 (60), 4 (90), 5 (120) degrees, then one of the tangents equals the chord joining the points of tangency.
- .....16. The median of a right triangle is drawn from the right angle to the hypotenuse. The projection of the median upon either leg of the triangle is 1 (one-third), 2 (one-fourth), 3 (one-half), 4 (three-fourths) of that leg.
- .....17. Tangents to two intersecting circles from any point in their common chord produced are 1 (parallel), 2 (perpendicular), 3 (equal), 4 (form a straight line), 5 (equal and perpendicular).
- .....18. All angles inscribed in a semi-circle are 1 (acute), 2 (obtuse), 3 (right), 4 (adjacent), 5 (complementary).
- .....19. It will take 1 (three), 2 (five), 3 (six), 4 (seven), 5 (nine) lines to draw the altitudes, medians, and bisectors of the angles of an isosceles triangle.
- .....20. If the diagonals are equal, perpendicular to each other, bisect the angles and bisect each other, the figure is a 1 (rectangle), 2 (trapezoid), 3 (rhombus), 4 (square), 5 (parallelogram).
- .....21. The angle formed by the bisectors of two exterior angles of a triangle equals 1 (twice the sum), 2 (half the sum), 3 (the sum of), 4 (the difference), the two interior angles at the vertices where the two exterior angles were bisected.
- .....22. The angle between two tangents to a circle is measured by 1 (one-half), 2 (twice), 3 (the complement), 4 (the supplement) of the smaller of the intercepted arcs.
- .....23. The perimeter of an inscribed equilateral triangle is equal to 1 (one-half), 2 (one-third), 3 (one-fourth), 4 (two-thirds), 5 (three-fourths) the perimeter of the circumscribed equilateral triangle.
- .....24. If the diagonals of a quadrilateral bisect each other at right angles and the shorter diagonal equals one side, the quadrilateral has two angles of 1 (30), 2 (45), 3 (90), 4 (120), 5 (150) degrees each.
- .....25. P is any point within a parallelogram ABCD. Draw lines from P to the four vertices. The sum of the triangles PAB and PCD is 1 (three-fourths), 2 (two-thirds), 3 (one-half), 4 (four-fifths), 5 (one-fourth) the area of the parallelogram.

(Turn to Page 20 and continue)

---

(Use this space for figuring)

- .....26. A common external tangent drawn to two circles cuts the line of centers produced. The radii drawn to the points of contact form two 1 (congruent), 2 (isosceles), 3 (similar), (obtuse), 5 (equal) triangles.
- .....27. An angle formed by two chords intersecting is equal in degrees to 1 (the sum), 2 (the difference), 3 (the product), 4 (one-half the sum), 5 (one-half the difference), 6 (one-half the product) of the intercepted arcs.
- .....28. ABCD is a parallelogram and P is any point on one diagonal. P is connected with each of the other vertices thereby forming two pairs of 1 (equal), 2 (similar), 3 (right), 4 (congruent), 5 (obtuse) triangles.
- .....29. If an angle of a triangle is unchanged, but each of the two including sides is doubled, the area is 1 (twice), 2 (three times), 3 (four times), 4 (one-half) as great.
- .....30. If one of the angles of a regular polygon contains 140 degrees, the polygon has 1 (three), 2 (five), 3 (seven), 4 (nine), 5 (eleven) sides.
- .....31. If the base of a rectangle is double that of a second rectangle, but the altitude of the first is half that of the second, the ratio of their areas is 1 (2:1), 2 (1:2), 3 ( $\frac{1}{2}$ :2), 4 ( $\frac{1}{2}$ :1), 5 (1:1).
- .....32. If my watch registers 12 o'clock the same time that Mr. B's watch registers 9 o'clock he is 1 (15), 2 (30), 3 (45), 4 (60), 5 (180) degrees west of me.
- .....33. When the shadow of a flag pole is longer than the pole itself, the sun's rays strike the earth at an angle of 1 (less than 45 degrees), 2 (45 degrees), 3 (more than 45 degrees), 4 (90 degrees), 5 (more than 90 degrees).
- .....34. The bisectors of the exterior angles of any quadrilateral form a quadrilateral whose opposite angles are 1 (right), 2 (equal), 3 (complementary), 4 (supplementary).
- .....35. Of the regular polygons having a given area the 1 (square), 2 (pentagon), 3 (hexagon), 4 (octagon), 5 (decagon) has the least perimeter.
- .....36. Regular 1 (pentagons), 2 (hexagons), 3 (octagons), 4 (decagons) can be used as patterns for a solid design.
- .....37. If the difference between the centers of two circles is equal to the difference of their radii, the circles are 1 (equal), 2 (concentric), 3 (tangent externally), 4 (tangent internally).
- .....38. If the radii of a circle drawn to the ends of a chord, equal the chord in length, the chord subtends a central angle of 1 (45 degrees), 2 (60 degrees), 3 (90 degrees), 4 (120 degrees), 5 (135 degrees).
- .....39. The comparative sum of the exterior angles of a decagon with those of a pentagon is 1 (twice), 2 (half), 3 (equal), 4 (dependent on the size of the interior angles), 5 (dependent upon the comparative lengths of the sides).
- .....40. The altitudes of an acute triangle meet in a point which is 1 (inside), 2 (outside), 3 (on one of the vertices of), 4 (on one of the sides of), the triangle.
- .....41. The diameter of a circle inscribed in an equilateral triangle is equal to 1 (one-third), 2 (one-fourth), 3 (one-half), 4 (two-thirds), 5 (three-fourths) the altitude of a triangle.
- (Do not break the next seal until told to do so.)

(Use this space for figuring)

**PART IV. CONSTRUCTIONS.**

**DIRECTIONS:** Construct using ruler and compass. Make all arcs, lines, etc. distinctly visible for the examiner.

1. The three dots A, B, C, represent three kitchen doors. A well is to be dug equidistant from each door. Locate the well.

. A

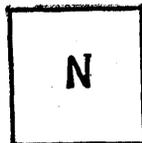
. B

. C

2. Reduce the line segment PQ in the ratio 3:2.

P ————— Q

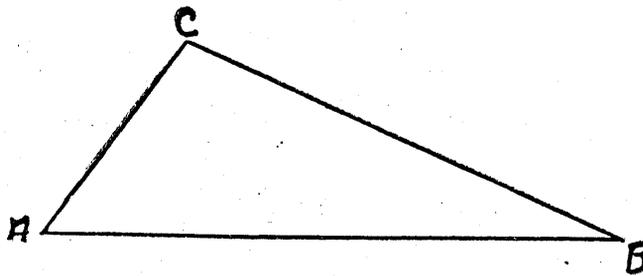
3. Construct a square equal in area to the squares M and N.



(Continue on opposite page)

4. Construct a five-pointed star.

5. Divide the triangle into three equal parts by lines drawn from any one vertex.



-END-

(Experimental Use Only)

FORM A

# ACHIEVEMENT TEST IN PLANE GEOMETRY

By MAUDE McMINDES

Principal Senior High School, Hays, Kansas

Name..... Grade.....

Age .....years ..... months. Boy or girl.....

Date..... School .....

City..... State .....

Number of months you studied geometry.....

| TIME    | PART  | SCORE |
|---------|-------|-------|
| 20 min. | I     |       |
| 10 min. | II    |       |
| 30 min. | III   |       |
|         | Total |       |

(To be Read by Teacher and Student)

**GENERAL DIRECTIONS:** This test consists of three parts and requires 60 minutes of actual working time. The seals are so arranged that each part can be given in the time allowed for that particular part or it can be given in one 60-minute period, instructing the student to break the seal and continue if he finishes any part before time is called. If you have not finished a particular part when time is called, you should leave that part unfinished and begin on the next part. An eraser, ruler and several pencils are needed. Do not provide any scratch paper. Blank pages are provided for all necessary figuring. Directions and examples of how answers are to be stated are given with each part. First go through the list and answer those you are sure of. If you have time, go back and try those you have left unsolved. Do not depend on guessing. It does not pay. Your greatest asset will be to read the problem correctly and do what you are told to do.

**SPECIAL INSTRUCTIONS TO EXAMINERS:** Pass out one copy to each student, instructing them to not open the test booklet until told to do so. (Fill in blanks at the top of this page.) Read the general directions slowly and in a clear tone. Be sure the student thoroughly understands what he is expected to do. He deserves this. He is not being tested on his ability to decipher the plan of procedure, but his knowledge of geometry. No questions should be permitted after the test begins.

The test has been arranged to accommodate time schedules in use in various schools. It can be given in one continuous working period of 60 minutes or it can be given at time intervals as arranged for each part. If the latter plan is used, it is advisable to give the test on successive days until completed and begin counting time when the test booklet is opened to the page where the part begins.

If the test is given in one continuous working period of 60 minutes, begin counting time when the test booklet is opened to Page 2. Announce when the time for each part is up. If a student has not finished any part when time is called, instruct him to leave that part unfinished and begin on the next part. If a student finishes any part before time is called, instruct him to break the seal and continue.

The student deserves quiet surroundings while being tested.

## PART I. TRUE-FALSE TEST

**DIRECTIONS:** If the statement is true, place a + sign on the dotted line before it. If the statement is false, place a 0 sign on the dotted line before it. Do not guess. Solve the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

**EXAMPLE:**

- ..+.. 1. There are 180 degrees in the angles of a triangle.  
 ..0.... 2. Isosceles triangles are equilateral.
- 

- ..... 1. The bisector of the vertex angle of an isosceles triangle is perpendicular to the base.  
 ..... 2. A rectangle is a parallelogram, therefore a parallelogram is a rectangle.  
 ..... 3. If a diameter bisects an arc of a circle, it bisects the chord of the arc at right angles.  
 ..... 4. Tangents drawn to a circle from a point outside are equal.  
 ..... 5. The converse of a theorem can be accepted without proof.  
 ..... 6. Two right triangles are congruent if the hypotenuse and a side of one are equal to the hypotenuse and a side of the other.  
 ..... 7. The radius of a regular inscribed polygon bisects the angle to whose vertex it is drawn.  
 ..... 8. The diagonals of a rhombus intersect each other at right angles.  
 ..... 9. If two angles of a quadrilateral are supplementary, the other two are supplementary also.  
 .....10. The ratio of a circumference to the diameter of a circle is constant for all circles.  
 .....11. In a right triangle the middle point of the hypotenuse is equidistant from the three vertices.  
 .....12. All right triangles are equal.  
 .....13. The lines joining the mid-points of the sides of a triangle form four equilateral triangles.  
 .....14. If one square is double another square in area, the side of the first square is twice that of the second square.  
 .....15. A circle may be drawn through any three points.  
 .....16. If one side of a triangle is divided into two parts by a perpendicular from the opposite vertex, each part of that side is less than the adjacent side of the triangle.  
 .....17. The locus of all points equidistant from the vertices of a triangle is the intersection of the perpendicular bisectors of the sides.  
 .....18. If each of the equal sides of an isosceles triangle is greater than the third side, the vertex angle is greater than 60 degrees.  
 .....19. If two chords bisect each other they pass through the center of the circle.

(Turn to Page 4 and continue)

(Use this Space for Figuring)

- .....20. The area of a trapezoid equals the product of the median and one of the non-parallel sides.
- .....21. A plane is a surface such that the line joining any two points within it lies wholly on the surface.
- .....22. If two lines form equal adjacent angles, they are perpendicular to each other.
- .....23. If one side of a right triangle is half the hypotenuse, the smaller acute angle contains 30 degrees.
- .....24. All rhombuses are similar.
- .....25. A quadrilateral with one pair of sides equal and parallel is a trapezoid.
- .....26. Pattern makers use the carpenter's square to determine a semicircle. If the right angle of the square touches the curve at all points while the sides rest on the ends of the arc, it is a semicircle.
- .....27. The sum of the three altitudes of a triangle is less than the perimeter.
- .....28. The perimeter of any regular circumscribed polygon approaches the circumference of the circle as a limit as the number of sides is indefinitely increased.
- .....29. A circle can always be circumscribed about a quadrilateral whose opposite angles together equal 180 degrees.
- .....30. The lines joining the mid-points of the adjacent sides of any quadrilateral form a parallelogram.
- .....31. If the angles made by the non-parallel sides of a trapezoid with either of the parallel sides are equal, the trapezoid is isosceles.
- .....32. Three regular hexagons are constructed on the three sides of a right triangle. The largest equals the sum of the other two.
- .....33. The area of a sector of a circle equals the product of its radius and its arc.
- .....34. If one side of a triangle is produced in both directions, the sum of the exterior angles of the triangle adjacent to this line is greater than two right angles.
- .....35. Lines that never meet are said to be parallel.
- .....36. A pair of shears has the blades twice as long as the handles. The ends of the handles are always twice as far apart as the ends of the blades.
- .....37. Two triangles are similar if their sides are respectively perpendicular to each other.
- .....38. The angle made by the bisectors of the base angles of an isosceles triangle is equal to an exterior angle at the base.
- .....39. If  $\frac{a}{b} = \frac{c}{d}$  then  $\frac{a+b}{c} = \frac{b+c}{d}$
- .....40. The converse of this statement is true: "A square is a rectangular having four equal sides."
- .....41. As the number of sides of a polygon increases by 1, the sum of its angles increases by 2 right angles.
- .....42. If two chords intersect in a circle the sum of the segments of one equal the sum of the segments of the other.

(Turn to Page 6 and continue)

(Use this Space for Figuring)

- .....43. A rectangle and an oblique parallelogram have the same base and equal altitudes. The rectangle has the greater perimeter.
- .....44. If a drawing is enlarged, the angles are enlarged in the same ratio.
- .....45. Through the ends of the diameter two chords are drawn making with the diameter angles 55 degrees and 40 degrees, respectively. The first chord is longer than the second.
- .....46. The sum of lines, drawn from a point within a triangle to the vertices is greater than half the perimeter of the triangle.
- .....47. If a line drawn through one of the base angles of an isosceles triangle makes an angle with the base equal to one-half the vertex angle, this line is perpendicular to the opposite leg.
- .....48. Three circles pass through two given points. Their diameters bisecting the common chord connecting these two points form a straight line.
- .....49. If two triangles are similar, altitudes drawn from corresponding vertices are in the same ratio as the corresponding sides.
- .....50. If two triangles have an angle of the one supplementary to the angle of the other, they are to each other as the product of the sides including the angle of the first is to the product of the sides including the angle of the second.
- .....51. If two chords intersect within a circle and make equal angles with the radius drawn through the point of intersection, the chords are equal.
- .....52. The difference between the diagonals of a quadrilateral is less than the sum of either pair of opposite sides.
- .....53. The line of centers of two intersecting circles is the perpendicular bisector of their common chord.
- .....54. Two points each equidistant from the ends of a chord determine the diameter of the circle.
- .....55. A segment is divided by a given point into extreme and mean ratio when one part is the mean proportional between the whole segment and the other part.
- .....56. Two lines are crossed by a third line. The lines are parallel if the two interior angles on the same side of the transversal are  $1\frac{1}{2}$  right angles and 36 degrees respectively.
- .....57. The bisectors of the angles of a parallelogram are concurrent.
- .....58. Two regular polygons one having twice the number of sides of the other are circumscribed about the same circle. The one with the greater number of sides has the greater perimeter.
- .....59. A triangle has twice as many exterior angles as it has interior angles.
- .....60. If a polygon is equilateral it is equiangular.
- .....61. Through the vertices of a quadrilateral straight lines are drawn parallel to the diagonals. The newly formed quadrilateral is twice the size of the original quadrilateral.
- .....62. The line of centers of two internally tangent circles is equal to the sum of the two radii.
- .....63. If a central angle be doubled, its chord is doubled.

(Turn to Page 8 and continue)

(Use this Space for Figuring)

- .....64. The diameter is a cord, forms a sector, forms a segment, forms a semicircle, and is a secant in a circle.
- .....65. The sum of the squares of the diagonals of a rhombus equals the sum of the squares of the four sides.
- .....66. Two parallelograms are congruent if they have two sides and an angle of one equal to two sides and an angle of the other.
- .....67. In any right triangle the perpendicular from the vertex of the right angle to the hypotenuse is the mean proportion between the sides of the right triangle.
- .....68. Regular pentagons can be used to fill the angular magnitude about a point without overlapping.
- .....69. The greatest distance one can see from an airplane to the earth's surface is the mean proportional between the diameter of the earth and the height of the plane above the earth.
- .....70. Areas of similar figures are to each other as their corresponding sides.
- .....71. With a ruler and compass a square can be constructed which has the same area as a given circle.
- .....72. A common internal tangent to two circles bisects the line of centers.
- .....73. Rectilinear figures are bounded by straight lines intersecting at right angles.
- .....74. If two polygons are mutually equiangular they are similar.
- .....75. Two parallelograms are equal if they have two angles and a side of one equal respectively to two angles and a side of the other.

(END PART I)

ACHIEVEMENT TEST IN PLANE GEOMETRY

9

(Use this Space for Figuring)

## PART II. MULTIPLE CHOICE

GENERAL DIRECTIONS: Select the one word or group of words that makes the statement true. Write the letter number of the word or group of words on the dotted line at the left of the statement. Solve the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

## EXAMPLE:

.....1. A figure bounded by four straight lines is called (a) triangle, (b) decagon, (c) pentagon, (d) hexagon, (e) quadrilateral.

- ..... 1. Vertical angles are always (a) complementary, (b) supplementary, (c) acute, (d) obtuse, (e) equal.
- ..... 2. Concentric circles have the same (a) radii, (b) circumference, (c) centers, (d) areas.
- ..... 3. The line drawn from any vertex to the mid-point of the opposite side of a triangle is the (a) bisector of the angle, (b) mean proportion between the segments of the opposite side, (c) median, (d) altitude from vertex to opposite side.
- ..... 4. On a warship, a cannon, which shoots ten miles, brings into danger all persons within a radius of (a) 5, (b) 10, (c) 20, (d) 63 $\frac{1}{2}$ , (e) 314 $\frac{1}{2}$  miles.
- ..... 5. Two angles having a commonside and a common vertex are (a) acute, (b) obtuse, (c) equal, (d) adjacent, (e) vertical.
- ..... 6. A perpendicular erected at the mid-point of one of the sides of a regular polygon and extended to the center of the polygon is the (a) apothem, (b) diagonal, (c) tangent, (d) chord, (e) secant.
- ..... 7. In any (a) acute, (b) obtuse, (c) right, (d) equilateral, (e) isosceles triangle, the bisector of any angle forms two congruent triangles.
- ..... 8. The sum of the exterior angles of a regular polygon is (a) 180, (b) 360, (c) 1080, (d) 1440, (e) 2880 degrees.
- ..... 9. I am given a line equal to the perimeter of a rhombus. The number of rhombuses I can construct with this line equal to the perimeter is (a) 1, (b) 2, (c) 4, (d) unlimited.
- .....10. The bisectors of the angles, the medians and the altitudes coincide in (a) acute, (b) right, (c) scalene, (d) isosceles, (e) equilateral triangles.
- .....11. The mid-points of two sides of a triangle are jointed to any point in the third side. The area of the quadrilateral thus formed is (a)  $\frac{1}{3}$ , (b)  $\frac{1}{4}$ , (c)  $\frac{1}{2}$ , (d)  $\frac{2}{3}$ , (e)  $\frac{3}{4}$  the area of the triangle.
- .....12. If through any point in the bisector of an angle a line is drawn parallel to either of the sides of the angle, the triangle thus formed is (a) isosceles, (b) right, (c) equilateral, (d) obtuse.
- .....13. An angle inscribed in a segment smaller than a semicircle is (a) acute, (b) obtuse, (c) right, (d) straight.
- .....14. There can be found in one of the equal sides of an isosceles triangle (a) one, (b) two, (c) three, (d) many, (e) no points, equally distant from the extremities of the base.

(Turn to Page 12 and continue)

(Use this Space for Figuring)

- .....15. If one interior angle of a regular polygon contains 140 degrees, the polygon has (a) 3, (b) 5, (c) 7, (d) 9, (e) 11 sides.
- .....16. The bisectors of the exterior angles of a parallelogram form (a) an octagon, (b) isosceles trapezoid, (c) rhombus, (d) rectangle.
- .....17. Lines AB and CD bisect each other at P. CA is (a) equal, (b) parallel, (c) perpendicular, (d) equal and parallel, (e) equal and perpendicular, to BD.
- .....18. If the radii of a circle drawn to the ends of a chord equal the chord in length, the chord subtends a central angle of (a) 45, (b) 60, (c) 90, (d) 120, (e) 135 degrees.
- .....19. The greatest number of common tangents two circles can have is (a) one, (b) two, (c) three, (d) four, (e) five.
- .....20. When the sun's rays strike the earth at an angle of 48 degrees, the length of the tree's shadow is (a) shorter than, (b) longer than, (c) equal to, (d) exactly half, (e) exactly double, the height of the tree.
- .....21. The diagonals of a parallelogram divide it into four (a) equal, (b) similar, (c) congruent, (d) isosceles, (e) right triangles.
- .....22. The triangles ABC and ABD have a common base AB and the line CD is parallel to AB. The triangles are (a) similar, (b) equivalent, (c) congruent, (d) right, (e) isosceles.
- .....23. Tangents to two interesting circles from any point in their common chord produced are (a) parallel, (b) perpendicular, (c) equal, (d) equal and perpendicular, (e) form a straight line.
- .....24. If the median equals one-half the side it bisects, the triangle is (a) isosceles, (b) equilateral, (c) scalene, (d) obtuse, (e) right.
- .....25. The angle formed by the bisectors of two exterior angles of a triangle equals (a) twice the sum, (b) half the sum, (c) the sum of, (d) the difference of, the two interior angles at the vertices where the two exterior angles are bisected.
- .....26. Two roads intersect. The number of points equidistant from the two roads and ten miles from the intersection of the roads is (a) 1, (b) 2, (c) 3, (d) 4, (e) indefinite.
- .....27. If the difference between the centers of two circles is equal to the difference of their radii, the circles are (a) equal, (b) concentric, (c) tangent externally, (d) tangent internally.
- .....28. The locus of the vertices of all triangles having a common base and the same area is (a) one point, (b) two points, (c) a line parallel to the base, (d) two lines one on either side and parallel to the base.
- .....29. The three medians of a triangle divide the triangle into six (a) similar, (b) congruent, (c) equal, (d) right, (e) isosceles, triangles.
- .....30. The angle between two tangents to a circle is measured by (a) one-half, (b) twice, (c) the complement, (d) the supplement of the smaller, of the intercepted arcs.
- .....31. The comparative sum of the exterior angles of a decagon with the exterior angles of a pentagon is (a) twice, (b) half, (c) equal, (d) dependent upon size of interior angles, (e) dependent upon comparative lengths of the sides.

(END PART II)

(Use this Space for Figuring)

PART III. PROBLEMS

DIRECTIONS: Find the answers to these problems and write them on the dotted lines to the left. Solve the easy ones first, then go back to the harder ones later. If it is necessary to extract the square root, carry to one decimal place. Use the opposite page for figuring.

EXAMPLE:

- ..40....1. Find the third angle of a triangle if two of the angles are 50 degrees and 90 degrees respectively.

- ..... 1. How many degrees in a straight angle?
- ..... 2. How many inches in the perimeter of the square in Figure A?
- ..... 3. A gate post 4 feet high casts a shadow 18 feet long at the same time a house casts a shadow 144 feet long. How tall is the house?
- ..... 4. How many degrees in angle "r" of Figure B?
- ..... 5. How many inches in the perimeter of the hexagon in Figure A?
- ..... 6. An arc of a circle containing 24 degrees is 2 feet long. Find the circumference of the circle.
- ..... 7. How many degrees in angle "z" of Figure A?
- ..... 8. Determine the angle formed by the bisectors of the base angles of a triangle which are 56 degrees and 36 degrees respectively.
- ..... 9. What is the length of the side of a square equal in area to a triangle whose base is 24 and whose altitude is 12 inches.
- .....10. What is the area of the circle in Figure B?

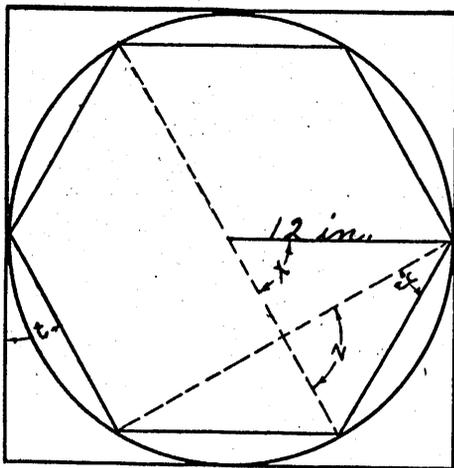


FIG. "A"

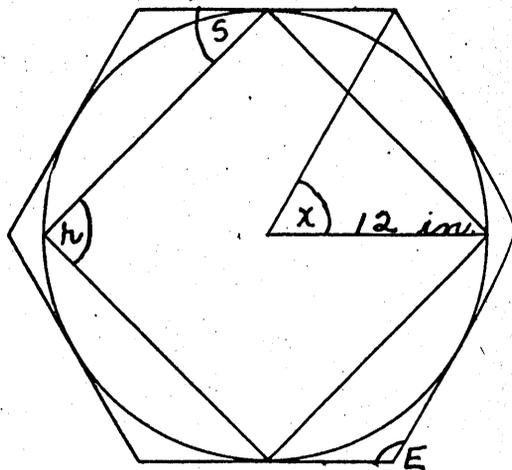


FIG. "B"

(Turn to Page 16 and continue)

(Use this Space for Figuring)

- .....11. How many degrees in angle "t" of Figure A?
- .....12. Two sides of a triangle are 16 feet and 20 feet. A line parallel to the third side cuts the 16 ft. side 5 feet from the vertex. How many feet in the segment joining the vertex on the 20 ft. side?
- .....13. If an acute angle of a triangle remains the same, but each of the two including sides is doubled, how many times is the area increased?
- .....14. The diagonals of a rhombus are 10 feet and 12 feet respectively. What is its area?
- .....15. The perimeter of an inscribed equilateral triangle is 28 inches. What is the perimeter of a circumscribed equilateral triangle of the same circle?
- .....16. A stairway rising at an angle of 30 degrees leads from one floor to another 12 feet above. Find the length of the railing.
- .....17.

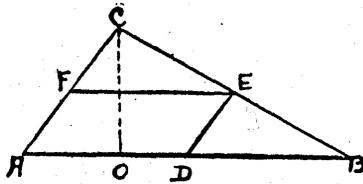


FIG. "C"

In the triangle ABC, (Figure C) through E the midpoint of CB parallels to the side AB, and AC are drawn. The side AB is 30 inches and the altitude CO is 10 inches. Required the area of ADEF.

- .....18. How many people can be seated at a round table 42 inches in diameter after it has been extended 2 feet, allowing 20 inches to one person?
- .....19. The perimeter of a triangle is 30 inches and the sides are in the ratio of 5:7:8. What is the length of the longest side?
- .....20. The radius of a circle is 12 inches. Find the radius of a concentric circle dividing the given circle into two equal areas.
- .....21.

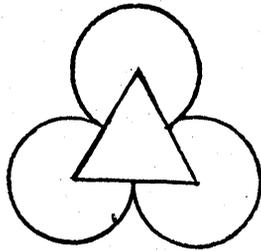


FIG. "D"

A trefoil (figure D) is constructed by drawing the arcs of circles with centers at the vertices of an equilateral triangle and radii equal to one-half the side of the triangle. If the side of the triangle is 14 inches, what is the perimeter of the trefoil?

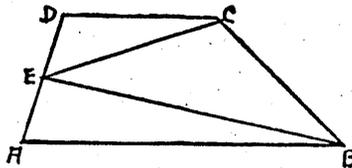
- .....22. The sides of a triangle are 8, 10, 12 inches. Find the short segment into which the 12-inch side is divided by the bisector of the interior angle opposite the 12-inch side.
- .....23. The square on the base of an equilateral triangle contains 1600 square feet. What is the area of a square built on the altitude of the same triangle.

(Turn to Page 18 and continue)

(Use this Space for Figuring)

.....24. The arch above a door 8 feet wide has a height of 2 feet. What is the radius of the circle of which the arch is an arc?

.....25.



ABCD is a trapezoid with E the midpoint of AD. The perpendicular distance between the parallel bases is 10 inches. The bases are 20 and 25 inches. Required the area of the triangle BEC.

FIG. "E"

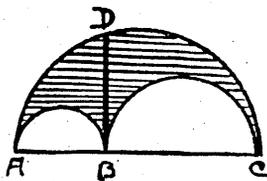
.....26. In order to find the approximate diameter of a porch column, a point C 3 feet from the circumference was selected. A tangent from this point to the column measured 5 feet. Required the diameter of the column.

.....27. An isosceles triangle has a side 10 inches and an area 30 square inches. A line drawn parallel to the base cuts off a triangle whose area is 18 square inches. Find one of the equal sides of the smaller triangle.

.....28. What is the area of the circumscribed hexagon in Figure B? Page 16.

.....29. The area of a regular hexagon is 36 square inches. The diagonals joining the alternate vertices are drawn to form a second regular hexagon. Required the area of the newly formed hexagon.

.....30.



B is any point on the line AC. Semi-circles are drawn with AB, BC, AC as diameters. DB is perpendicular to AC and is 7 inches long. What is the area of the shaded surface?

FIG. "F"

(END PART III)

(Use this Space for Figuring)

(Experimental Use Only)

FORM B

# ACHIEVEMENT TEST IN PLANE GEOMETRY

By MAUDE McMINDES

Principal Senior High School, Hays, Kansas

Name..... Grade.....

Age .....years ..... months. Boy or girl.....

Date..... School .....

City..... State .....

Number of months you studied geometry.....

| TIME    | PART  | SCORE |
|---------|-------|-------|
| 20 min. | I     |       |
| 10 min. | II    |       |
| 30 min. | III   |       |
|         | Total |       |

(To be Read by Teacher and Student)

**GENERAL DIRECTIONS:** This test consists of three parts and requires 60 minutes of actual working time. The seals are so arranged that each part can be given in the time allowed for that particular part or it can be given in one 60-minute period, instructing the student to break the seal and continue if he finishes any part before time is called. If you have not finished a particular part when time is called, you should leave that part unfinished and begin on the next part. An eraser, ruler and several pencils are needed. Do not provide any scratch paper. Blank pages are provided for all necessary figuring. Directions and examples of how answers are to be stated are given with each part. First go through the list and answer those you are sure of. If you have time, go back and try those you have left unsolved. Do not depend on guessing. It does not pay. Your greatest asset will be to read the problem correctly and do what you are told to do.

**SPECIAL INSTRUCTIONS TO EXAMINERS:** Pass out one copy to each student, instructing them to not open the test booklet until told to do so. (Fill in blanks at the top of this page.) Read the general directions slowly and in a clear tone. Be sure the student thoroughly understands what he is expected to do. He deserves this. He is not being tested on his ability to decipher the plan of procedure, but his knowledge of geometry. No questions should be permitted after the test begins.

The test has been arranged to accommodate time schedules in use in various schools. It can be given in one continuous working period of 60 minutes or it can be given at time intervals as arranged for each part. If the latter plan is used, it is advisable to give the test on successive days until completed and begin counting time when the test booklet is opened to the page where the part begins.

If the test is given in one continuous working period of 60 minutes, begin counting time when the test booklet is opened to Page 2. Announce when the time for each part is up. If a student has not finished any part when time is called, instruct him to leave that part unfinished and begin on the next part. If a student finishes any part before time is called, instruct him to break the seal and continue.

The student deserves quiet surroundings while being tested.

## PART I. TRUE-FALSE TEST

**DIRECTIONS:** If the statement is true, place a + sign on the dotted line before it. If the statement is false, place a 0 sign on the dotted line before it. Do not guess. Solve the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

**EXAMPLE:**

- ....+....1. There are 90 degrees in a right angle.  
 .....0....2. All equilateral triangles are congruent.
- 

- ..... 1. The diagonals of a parallelogram bisect each other.  
 ..... 2. A right triangle can be isosceles.  
 ..... 3. Any side of a polygon is less than the sum of all the other sides.  
 ..... 4. The converse of the following is true: "If two sides of a triangle are equal, the angles opposite them are equal."  
 ..... 5. The supplement of an obtuse angle equals itself.  
 ..... 6. If the sides of a parallelogram are equal, the figure is a square.  
 ..... 7. If the perpendiculars from the center to two chords in the same circle are equal, the chords are equal.  
 ..... 8. The circumference of a circle is  $3\frac{1}{2}$  times its radius.  
 ..... 9. The diagonals of a regular pentagon are equal.  
 .....10. The bisectors of the angles of a square form a square.  
 .....11. By doubling the number of sides of an inscribed polygon indefinitely, the difference between the circumference of the circle and the perimeter of the polygon can be made as small as desired.  
 .....12. A line joining the mid-points of two sides of a triangle is equal to one-fourth the other side.  
 .....13. If two parallel lines are cut by a transversal, the bisectors of the four interior angles form a rectangle.  
 .....14. The lines joining the mid-points of the opposite sides of a quadrilateral bisect each other.  
 .....15. Radii forming 60 degree angles at the ends of a chord form with the chord an equilateral triangle.  
 .....16. The area of a triangle equals the product of its perimeter and the radius of an inscribed circle.  
 .....17. If two triangles have their sides respectively parallel, they are similar.  
 .....18. In the quadrilateral ABCD, AD is the longest side and BC the shortest side. Angle B is smaller than angle D.  
 .....19. The altitudes to the legs of an isosceles triangle are equal.

(Turn to Page 4 and continue)

(Use this Space for Figuring)

- .....20. If an inscribed angle and a central angle intercept the same arc in the same circle, they are equal.
- .....21. One of the equal sides of an isosceles triangle is sometimes less than half the base.
- .....22. The area of a trapezoid is equal to the product of the median and the altitude between the non-parallel bases.
- .....23. If a diagonal of a quadrilateral bisects the two angles between which it is drawn, it is perpendicular to the other diagonal.
- .....24. The line bisecting the exterior vertex angle of an isosceles triangle is perpendicular to the base.
- .....25. The radius of a circle circumscribed about a right triangle is equal to half the hypotenuse.
- .....26. A piece of paper has been cut for a kite with its upper edges 7 inches and its lower edges 16 inches. The cross sticks forming the frame work are perpendicular to each other.
- .....27. Two right triangles are congruent if the hypotenuse and a right angle of the one are equal to the hypotenuse and a right angle of the other.
- .....28. If the word "non-parallel" is omitted from the following theorem it is false: "If two nonparallel lines are cut by three or more parallels, the corresponding segments are proportional".
- .....29. If the acute angles of a right triangle are 30 degrees and 60 degrees respectively, the shorter side is equal in length to one-half the hypotenuse.
- .....30. The diagonals of a rhombus are equal.
- .....31. The angle between two tangents to a circle is the supplement of the angle between the radii drawn to the points of tangency.
- .....32. A median of a triangle divides the triangle into two equal triangles.
- .....33. The difference between two sides of a triangle is less than the third side.
- .....34. If any number of equal angles are inscribed in an arc, their bisectors pass through a common point.
- .....35. A segment of a circle may also be a sector of the same circle.
- .....36. If the dimensions of a rectangle are doubled, its area is also doubled.
- .....37. The converse of the following is true: "If a quadrilateral is a square its diagonals intersect at right angles."
- .....38. If I divide the circumference of a circle whose diameter is 10 inches into four equal parts and the circumference of a circle whose diameter is 5 inches into four equal parts, the central angle of the first is double the central angle of the second.
- .....39. The apothem of a regular polygon is the radius of the circumscribed circle.
- .....40. The square on one side of a square equals one-half the product of its diagonals.

(Turn to Page 6 and continue)

(Use this Space for Figuring)

- .....41. If  $\frac{a}{b} = \frac{c}{d}$ , then  $\frac{a}{d} = \frac{b}{c}$
- .....42. If two lines intersect, their sum is greater than the sum of either pair of joins of the ends of the lines.
- .....43. Two plots of ground, one a square and one a circle, each contain the same area. The circle has the greater perimeter.
- .....44. If two angles of a quadrilateral are right angles, all the angles are right angles.
- .....45. The bisector of an angle of a triangle divides the opposite side into segments proportional to the sides of the angle.
- .....46. The medians of a triangle intersect in a point which is one-half the distance from the vertex to the mid-point of the opposite side.
- .....47. The converse of the following is sometimes false: "Polygons are similar, if they can be decomposed into triangles which are similar and similarly placed."
- .....48. From a point P outside a circle whose center is O, secants are drawn. The locus of the mid-points of the chords so formed is the arc of a circle.
- .....49. A man is planning a house. The rectangular plan is 20x30 feet, making the perimeter of the house 100 feet. A second man has planned a square house with a perimeter of 100 feet. The first man has more floor area.
- .....50. The sum of the squares on the four sides of a parallelogram equals the sum of the squares of the diagonals.
- .....51. The bisectors of the angles of a triangle meet in a point equidistant from the three vertices.
- .....52. A central angle and a vertex angle of any regular polygon are supplementary.
- .....53. The angle of a triangle is either acute, right or obtuse according as the square of the opposite side is less than, equal to, greater than the sum of the squares on the other two sides.
- .....54. Lines are drawn from a vertex of a triangle to the opposite side cutting that side into three equal divisions. The three triangles thus formed are equal.
- .....55. The lines joining the mid-points of the adjacent sides of an isosceles trapezoid form a rectangle.
- .....56. Tangents drawn at the middle points of the arc subtended by sides of a regular inscribed polygon form another polygon of the same number of sides.
- .....57. If an equilateral triangle is inscribed in a circle, the distance of each side from the center is equal to half the radius of the circle.
- .....58. If lines be drawn from any vertex of a parallelogram to the mid-points of the opposite sides they will divide the diagonals which they intersect into three equal parts.
- .....59. Tangents to a circle from a point outside are perpendicular to the chord joining the points of contact.
- .....60. The locus of the mid-points of a system of equal chords is the diameter.
- .....61. Four equal angles complete the opening about a point on one side of a straight line. Each angle is 90 degrees.

(Turn to Page 8 and continue)

(Use this Space for Figuring)

- .....62. The shortest distance to the circumference of a circle from a point without the circle is along the tangent from this point.
- .....63. Any two altitudes of a triangle are proportional to the sides to which they are perpendicular.
- .....64. If unequals be subtracted from equals the remainders are unequal in the same order.
- .....65. A triangle may be constructed with any three parts given.
- .....66. If three straight lines drawn through a common point intersect two parallels, the corresponding segments of the parallels are in proportion.
- .....67. The sum of the perpendiculars from any point within an equilateral triangle to the sides is equal to the altitude of the triangle.
- .....68. All rectangles, excluding the square, are similar.
- .....69. The projection of a line segment may be greater than, less than, or equal to the line segment itself.
- .....70. If a chord is lengthened, the central angle subtended is increased in the same ratio.
- .....71. The bisectors of two exterior angles of any triangle and the bisector of the non-adjacent interior angle concur.
- .....72. If two secants are drawn to a circle from an external point, the sum of one secant and its external segments is equal to the sum of the other secant and its external segment.
- .....73. If two circles are externally tangent and a line intersecting the circles is drawn through the point of contact, diameters drawn from the points of intersection are parallel.
- .....74. If two quadrilaterals have their sides proportional, they are similar.
- .....75. Thirty-three diagonals may be drawn in a polygon of eleven sides.

END PART I

(Use this Space for Figuring)

## PART II. MULTIPLE CHOICE

GENERAL DIRECTIONS: Select the one word or group of words that makes the statement true. Write the letter number of the word or group of words on the dotted line at the left of the statement. Solve the easy ones first, then go back to the harder ones later. Use the opposite page for figuring.

## EXAMPLE:

....d....1. A figure bounded by four straight lines is called (a) a triangle, (b) a decagon, (c) a pentagon, (d) a quadrilateral.

- ..... 1. All angles inscribed in a semi-circle are (a) acute, (b) obtuse, (c) right, (d) adjacent, (e) complementary.
- ..... 2. If the diagonals are equal, perpendicular to each other, bisect the angles and bisect each other, the figure is a (a) rectangle, (b) trapezoid, (c) rhombus, (d) square.
- ..... 3. A circle may be inscribed in any (a) triangle, (b) quadrilateral, (c) pentagon, (d) hexagon, (e) decagon.
- ..... 4. Three angles of one triangle equal respectively to three angles of another triangle make the triangles (a) equal, (b) acute, (c) similar, (d) congruent, (e) equilateral.
- ..... 5. If the angle at the center of a regular polygon is 40 degrees, the polygon has (a) 4, (b) 6, (c) 8, (d) 9, (e) 10 sides.
- ..... 6. The altitudes of an obtuse triangle meet in a point which is (a) inside, (b) outside, (c) on one of the vertices of, (d) on one of the sides of the triangle.
- ..... 7. P is any point within a parallelogram ABCD. Draw lines from P to the four vertices. The sum of the triangles PAB and PCD is (a)  $\frac{2}{3}$ , (b)  $\frac{2}{3}$ , (c)  $\frac{1}{2}$ , (d)  $\frac{1}{3}$ , (e)  $\frac{1}{4}$ , the area of the parallelogram.
- ..... 8. The median of a right triangle is drawn from the right angle to the hypotenuse. The projection of the median upon either leg of the triangle is (a)  $\frac{1}{3}$ , (b)  $\frac{1}{4}$ , (c)  $\frac{1}{2}$ , (d)  $\frac{2}{3}$ , of that leg.
- ..... 9. If each side of an equilateral triangle is divided into three equal parts and the adjacent points connected, a hexagon is formed whose area is (a) one-half, (b) equal, (c) two-thirds, (d) three fourths the original triangle.
- .....10. An angle formed by two chords intersecting within the circle is equal in degrees to (a) the sum, (b) the difference, (c) the product, (d) one-half the sum, (e) one-half the difference, (f) one-half the product of the intercepted arcs.
- .....11. When the shadow of a flag pole is longer than the pole itself, the sun's rays strike the earth at an angle of (a) less than 45 degrees, (b) 45 degrees, (c) more than 45 degrees (d) 90 degrees, (e) more than 90 degrees.
- .....12. If two tangents drawn from a point to a circle form an angle of (a) 30, (b) 45, (c) 60, (d) 90, (e) 120, degrees, then one of the tangents equals the chord joining the points of tangency.
- .....13. If the base of a rectangle is double that of a second rectangle, but the altitude of the first is half that of the second, the ratio of their areas is (a) 2:1, (b) 1:2, (c)  $\frac{1}{2}$ :2, (d) 1:1.
- .....14. Two concentric circles have at most (a) no, (b) 1, (c) 2, (d) 3, (e) unlimited number of, points in common.

(Turn to Page 12 and continue)

(Use this Space for Figuring)

- .....15. The perimeter of an inscribed equilateral triangle is equal to (a)  $\frac{1}{3}$ , (b)  $\frac{1}{2}$ , (c)  $\frac{1}{4}$ , (d)  $\frac{2}{3}$ , (e)  $\frac{3}{4}$ , the perimeter of an equilateral triangle circumscribed about the same circle.
- .....16. If an angle of a triangle is unchanged, but each of the two including sides is doubled the area is (a) twice, (b) three times, (c) four times, (d) one-half, as great.
- .....17. A common external tangent drawn to two circles cuts the line of centers produced. The radii drawn to the points of contact form two (a) congruent, (b) isosceles, (c) similar, (d) obtuse, (e) equal triangles.
- .....18. There are (a) 1, (b) 2, (c) three (d) 4, (e) indefinite number of, solutions possible for the following: On a given base construct a parallelogram equal to a given square.
- .....19. Two triangles are (a) congruent, (b) equilateral, (c) similar, (d) equal, if the two sides of the one are equal respectively to two sides of the other and the included angles are supplementary.
- .....20. In an isosceles trapezoid, the triangles formed by the two diagonals and the bases are (a) similar, (b) equal, (c) congruent, (d) equilateral, (e) right.
- .....21. The bisectors of the exterior angles of any quadrilateral form a quadrilateral whose opposite angles are (a) right, (b) equal, (c) complementary, (d) supplementary.
- .....22. If my watch registers 12 o'clock the same time that Mr. R's watch registers 9 o'clock he is (a) 15, (b) 30, (c) 45, (d) 60, (e) 180 degrees west of me.
- .....23. The diameter of a circle inscribed in an equilateral triangle is equal to (a)  $\frac{1}{3}$ , (b)  $\frac{1}{4}$ , (c)  $\frac{1}{2}$ , (d)  $\frac{2}{3}$ , (e)  $\frac{3}{4}$  the altitude of the triangle.
- .....24. The chord of 180 degrees angle is (a) equal to, (b) double, (c) three times, (d) four times the chord of a 60 degree central angle in the same circle.
- .....25. It will take (a) 3, (b) 5, (c) 6, (d) 7, (e) 9, lines to draw the altitudes, medians, and bisectors of the angles of an isosceles triangle.
- .....26. If the difference between the centers of two circles is equal to the difference of their radii, the circles are (a) equal, (b) concentric, (c) tangent externally, (d) tangent internally.
- .....27. ABCD is a parallelogram and P is any point on one diagonal. P. is connected with each of the other vertices thereby, forming two pairs of (a) equal (b) similar, (c) right, (d) congruent, triangles.
- .....28. Of the regular polygons having a given area the (a) square, (b) pentagon, (c) hexagon, (d) octagon, (e) decagon has the least perimeter.
- .....29. If the diagonals of a quadrilateral bisect each other at right angles and the shorter diagonal equals one side, the quadrilateral has two angles of (a) 30, (b) 45, (c) 90, (d) 120, (e) 150 degrees each.
- .....30. The locus of all points 4 inches from each of two given points which are 6 inches apart is (a) a circle, (b) one point, (c) two points, (d) a line parallel to the line joining the points.
- .....31. In the triangle ABC medians AE and CD intersect at point O. Triangle AOC is equal in area to (a) COE, (b) AOD, (c) BEOD, (d) none of the figures.

(END PART II)

(Use this Space for Figuring)

## PART III. PROBLEMS

**DIRECTIONS:** Find the answers to these problems and write them on the dotted lines to the left. Solve the easy ones first, then go back to the harder ones later. If it is necessary to extract the square root, carry to one decimal place. Use the opposite page for figuring.

**EXAMPLE:**

..20.....1. One of the acute angles of a right triangle is 70 degrees. How large is the other acute angle?

- ..... 1. How many degrees in one of the angles of a square?
- ..... 2. The base of a right triangle is 36 inches and its altitude is 20 inches. Determine its area.
- ..... 3. One of the interior angles of a triangle equals 70 degrees. How many degrees in its adjacent exterior angle?
- ..... 4. If the scale of a certain drawing is  $\frac{1}{4}$ " : 1', how many feet does a 6-inch line represent?
- ..... 5. What is the area of the square in Figure A?
- ..... 6. The bases of a trapezoid are 10 inches and 7 inches respectively and the altitude is 8 inches. Find the area.
- ..... 7. How many degrees in angle Y of Figure A?
- ..... 8. How many inches in the circumference of the circle in Figure A?
- ..... 9. How many degrees in angle E of Figure B?
- .....10. How many degrees in angle S of Figure B?

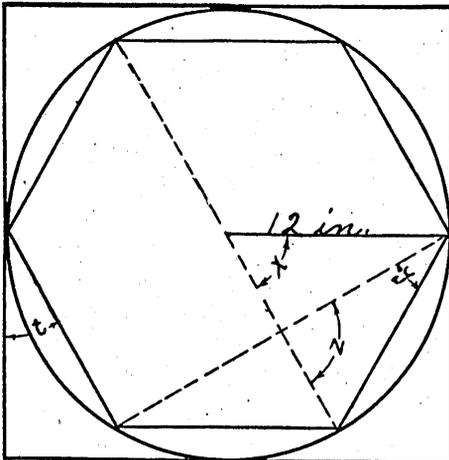


FIG. "A"

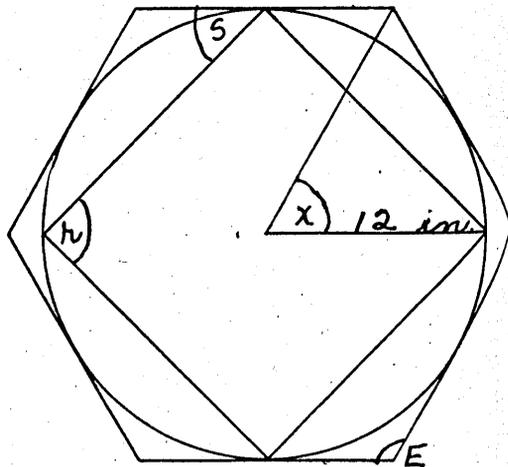


FIG. "B"

- .....11. One of the diagonals of a square is 12 inches. Determine its area.
- .....12. A 30 foot ladder is leaning against a building and making a 60 degree angle with the ground. How far is the foot of the ladder from the building?
- .....13. How many degrees in one of the angles of a five-pointed star?

(Turn to Page 16 and continue)

(Use this Space for Figuring)

- .....14. One of the interior angles of a regular polygon is 150 degrees. How many sides has the polygon?
- .....15. The angles of a quadrilateral are in the ratio of 1:2:3:4. Determine the size of the largest angle?
- .....16.

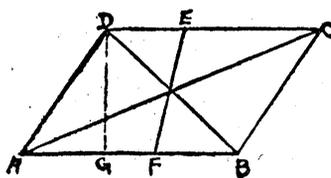


FIG. "C"

ABCD (Figure C) is a parallelogram. EF is any line drawn through the intersection of the diagonals. DG equals 20 inches and AB equals 40 inches. How many square inches in FBCE?

- .....17. What is the perimeter of the square in Figure B, page 14?
- .....18. A chord 18 inches long lies 12 inches from the center of the circle. Find the radius of the circle.
- .....19.

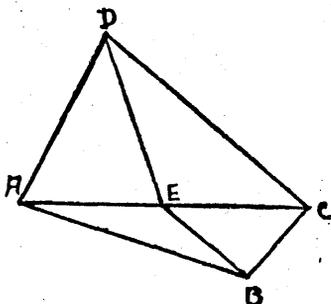


FIG. "D"

Given: Quadrilateral ABCD (Figure D) with E the midpoint of AC. The area of the given quadrilateral is 400 square inches. Determine area of DEBC.

- .....20. The area of a circumscribed square is 2500 square inches. What is the area of an inscribed square in the same circle?
- .....21. A wheel stands in water which reaches halfway to the center of the hub. How many degrees are there in the arc bounding the submerged portion?
- .....22. A piece of cloth 18 inches wide is to be cut on the bias at an angle of 45 degrees. How long is the bias cut?
- .....23. How many square inches in the area of the inscribed hexagon Figure A? Page 14.
- .....24. The base of a right triangle is 12 feet and the median on the hypotenuse is  $7\frac{1}{2}$  feet. Find the area of the triangle.
- .....25. Find the area of a triangle whose sides are 5, 6 and 7 inches respectively.

(Turn to Page 18 and continue)

(Use this Space for Figuring)

.....26.

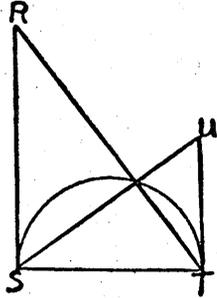


FIG. "E"

Given: Tangents RS equals 36 inches and TU equals 25 inches. Required the diameter of the semicircle.

.....27. The sides of a triangle are 3, 4 and 6 inches respectively. Find the longest side of a similar triangle whose area is 9 times as great.

.....28.

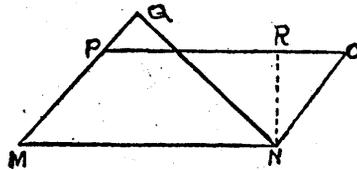


FIG. "F"

Given: Parallelogram MNOP,  $NR \perp$  to PO and  $NQ \perp$  MP. MN equals 40 inches; MP equals 20 inches. NR equals 15 inches. Required QN.

.....29. A man on the top of a mountain one mile high sees a ship just coming into view. How far is he from the ship? (Radius of earth = 4000 miles.)

.....30. Two men cut one-fourth of the distance through a round log. What fractional part of the log is cut?

(END PART III)

(Use this Space for Figuring)

Table I (a) True-False Section of Geometry test (Form A).  
A list of the test elements and the number of correct  
responses each received. First edition.

| No. of test<br>element | Correct<br>responses | No. of test<br>element | Correct<br>responses |
|------------------------|----------------------|------------------------|----------------------|
| 1                      | 801                  | 47                     | 512                  |
| 2                      | 536                  | 48                     | 154                  |
| 3                      | 394                  | 49                     | 156                  |
| 4                      | 311                  | 50                     | 451                  |
| 5                      | 535                  | 51                     | 352                  |
| 6                      | 563                  | 52                     | 241                  |
| 7                      | 245                  | 53                     | 558                  |
| 8                      | 778                  | 54                     | 399                  |
| 9                      | 430                  | 55                     | 543                  |
| 10                     | 427                  | 56                     | 339                  |
| 11                     | 207                  | 57                     | 332                  |
| 12                     | 508                  | 58                     | 259                  |
| 13                     | 400                  | 59                     | 578                  |
| 14                     | 378                  | 60                     | 297                  |
| 15                     | 563                  | 61                     | 234                  |
| 16                     | 678                  | 62                     | 219                  |
| 17                     | 412                  | 63                     | 494                  |
| 18                     | 536                  | 64                     | 445                  |
| 19                     | 450                  | 65                     | 163                  |
| 20                     | 411                  | 66                     | 325                  |
| 21                     | 425                  | 67                     | 385                  |
| 22                     | 349                  | 68                     | 402                  |
| 23                     | 320                  | 69                     | 406                  |
| 24                     | 409                  | 70                     | 288                  |
| 25                     | 507                  | 71                     | 444                  |
| 26                     | 664                  | 72                     | 300                  |
| 27                     | 356                  | 73                     | 269                  |
| 28                     | 567                  | 74                     | 146                  |
| 29                     | 468                  | 75                     | 264                  |
| 30                     | 176                  | 76                     | 259                  |
| 31                     | 482                  | 77                     | 228                  |
| 32                     | 492                  | 78                     | 241                  |
| 33                     | 518                  | 79                     | 131                  |
| 34                     | 268                  | 80                     | 225                  |
| 35                     | 488                  | 81                     | 233                  |
| 36                     | 402                  | 82                     | 289                  |
| 37                     | 749                  | 83                     | 304                  |
| 38                     | 729                  | 84                     | 185                  |
| 39                     | 224                  | 85                     | 202                  |
| 40                     | 501                  | 86                     | 232                  |
| 41                     | 295                  | 87                     | 77                   |
| 42                     | 472                  | 88                     | 137                  |
| 43                     | 456                  | 89                     | 210                  |
| 44                     | 772                  | 90                     | 238                  |
| 45                     | 221                  |                        |                      |
| 46                     | 571                  |                        |                      |

Table I (b) Problem Section of Geometry test (Form A).  
A list of the test elements and the number of correct  
responses each received.

| No. of test<br>element | Total points<br>answered |
|------------------------|--------------------------|
| 1                      | 790                      |
| 2                      | 633                      |
| 3                      | 513                      |
| 4                      | 1179                     |
| 5                      | 536                      |
| 6                      | 156                      |
| 7                      | 183                      |
| 8                      | 377                      |
| 9                      | 569                      |
| 10                     | 548                      |
| 11                     | 102                      |
| 12                     | 173                      |
| 13                     | 23                       |
| 14                     | 378                      |
| 15                     | 160                      |
| 16                     | 40                       |
| 17                     | 102                      |
| 18                     | 199                      |
| 19                     | 382                      |
| 20                     | 170                      |
| 21                     | 592                      |
| 22                     | 523                      |
| 23                     | 419                      |
| 24                     | 495                      |
| 25                     | 41                       |
| 26                     | 350                      |
| 27                     | 487                      |
| 28                     | 443                      |
| 29                     | 476                      |
| 30                     | 221                      |
| 31                     | 19                       |
| 32                     | 33                       |
| 33                     | 47                       |
| 34                     | 55                       |
| 35                     | 50                       |
| 36                     | 123                      |
| 37                     | 23                       |
| 38                     | 50                       |
| 39                     | 26                       |
| 40                     | 138                      |
| 41                     | 29                       |
| 42                     | 34                       |
| 43                     | 1                        |
| 44                     | 3                        |
| 45                     | 1                        |

Table I (c) Logical Selection Section of Geometry test (Form A). A list of the test elements and the number of correct responses each received.

| No. of test element | Total points answered |
|---------------------|-----------------------|
| 1                   | 682                   |
| 2                   | 664                   |
| 3                   | 544                   |
| 4                   | 133                   |
| 5                   | 298                   |
| 6                   | 99                    |
| 7                   | 432                   |
| 8                   | 159                   |
| 9                   | 196                   |
| 10                  | 370                   |
| 11                  | 476                   |
| 12                  | 232                   |
| 13                  | 314                   |
| 14                  | 552                   |
| 15                  | 455                   |
| 16                  | 238                   |
| 17                  | 244                   |
| 18                  | 284                   |
| 19                  | 255                   |
| 20                  | 357                   |
| 21                  | 163                   |
| 22                  | 288                   |
| 23                  | 311                   |
| 24                  | 167                   |
| 25                  | 111                   |
| 26                  | 117                   |
| 27                  | 157                   |
| 28                  | 231                   |
| 29                  | 462                   |
| 30                  | 581                   |
| 31                  | 464                   |
| 32                  | 205                   |
| 33                  | 465                   |
| 34                  | 332                   |
| 35                  | 320                   |
| 36                  | 222                   |
| 37                  | 148                   |
| 38                  | 217                   |
| 39                  | 27                    |
| 40                  | 173                   |
| 41                  | 115                   |
| 42                  | 84                    |

Table I (d) True-False Section of Geometry test (Form B).  
A list of the test elements and the number of correct responses each received.

| No. of test element | Correct responses | No. of test element | Correct responses |
|---------------------|-------------------|---------------------|-------------------|
| 1                   | 791               | 47                  | 357               |
| 2                   | 652               | 48                  | 585               |
| 3                   | 743               | 49                  | 451               |
| 4                   | 490               | 50                  | 328               |
| 5                   | 656               | 51                  | 501               |
| 6                   | 742               | 52                  | 496               |
| 7                   | 583               | 53                  | 214               |
| 8                   | 149               | 54                  | 468               |
| 9                   | 208               | 55                  | 284               |
| 10                  | 345               | 56                  | 430               |
| 11                  | 460               | 57                  | 160               |
| 12                  | 627               | 58                  | 367               |
| 13                  | 593               | 59                  | 191               |
| 14                  | 406               | 60                  | 272               |
| 15                  | 454               | 61                  | 159               |
| 16                  | 430               | 62                  | 178               |
| 17                  | 396               | 63                  | 304               |
| 18                  | 442               | 64                  | 604               |
| 19                  | 351               | 65                  | 568               |
| 20                  | 524               | 66                  | 201               |
| 21                  | 450               | 67                  | 264               |
| 22                  | 632               | 68                  | 238               |
| 23                  | 362               | 69                  | 442               |
| 24                  | 408               | 70                  | 311               |
| 25                  | 559               | 71                  | 487               |
| 26                  | 314               | 72                  | 317               |
| 27                  | 691               | 73                  | 316               |
| 28                  | 479               | 74                  | 226               |
| 29                  | 340               | 75                  | 195               |
| 30                  | 482               | 76                  | 226               |
| 31                  | 511               | 77                  | 70                |
| 32                  | 401               | 78                  | 225               |
| 33                  | 230               | 79                  | 241               |
| 34                  | 383               | 80                  | 200               |
| 35                  | 525               | 81                  | 253               |
| 36                  | 314               | 82                  | 186               |
| 37                  | 509               | 83                  | 278               |
| 38                  | 483               | 84                  | 236               |
| 39                  | 725               | 85                  | 292               |
| 40                  | 592               | 86                  | 194               |
| 41                  | 241               | 87                  | 89                |
| 42                  | 285               | 88                  | 276               |
| 43                  | 316               | 89                  | 121               |
| 44                  | 627               | 90                  | 120               |
| 45                  | 218               |                     |                   |
| 46                  | 573               |                     |                   |

Table I (e) Problem Section of Geometry test (Form B).  
A list of the test elements and the number of correct  
responses each received.

| No. of test<br>element | Correct<br>responses |
|------------------------|----------------------|
| 1                      | 815                  |
| 2                      | 711                  |
| 3                      | 269                  |
| 4                      | 93                   |
| 5                      | 61                   |
| 6                      | 168                  |
| 7                      | 200                  |
| 8                      | 492                  |
| 9                      | 52                   |
| 10                     | 85                   |
| 11                     | 22                   |
| 12                     | 168                  |
| 13                     | 39                   |
| 14                     | 109                  |
| 15                     | 80                   |
| 16                     | 188                  |
| 17                     | 52                   |
| 18                     | 21                   |
| 19                     | 198                  |
| 20                     | 71                   |
| 21                     | 27                   |
| 22                     | 14                   |
| 23                     | 137                  |
| 24                     | 36                   |
| 25                     | 382                  |
| 26                     | 148                  |
| 27                     | 23                   |
| 28                     | 352                  |
| 29                     | 439                  |
| 30                     | 353                  |
| 31                     | 315                  |
| 32                     | 530                  |
| 33                     | 81                   |
| 34                     | 40                   |
| 35                     | 24                   |
| 36                     | 58                   |
| 37                     | 23                   |
| 38                     | 17                   |
| 39                     | 35                   |
| 40                     | 94                   |
| 41                     | 64                   |
| 42                     | 23                   |
| 43                     | 34                   |

Table I (f) Logical Selection Section of Geometry test (Form B) A list of the test elements and the number of correct responses each received.

| No. of test element | Correct responses |
|---------------------|-------------------|
| 1                   | 788               |
| 2                   | 640               |
| 3                   | 317               |
| 4                   | 390               |
| 5                   | 562               |
| 6                   | 216               |
| 7                   | 446               |
| 8                   | 193               |
| 9                   | 241               |
| 10                  | 334               |
| 11                  | 255               |
| 12                  | 348               |
| 13                  | 110               |
| 14                  | 518               |
| 15                  | 310               |
| 16                  | 373               |
| 17                  | 170               |
| 18                  | 682               |
| 19                  | 157               |
| 20                  | 666               |
| 21                  | 161               |
| 22                  | 101               |
| 23                  | 284               |
| 24                  | 101               |
| 25                  | 377               |
| 26                  | 266               |
| 27                  | 347               |
| 28                  | 120               |
| 29                  | 271               |
| 30                  | 301               |
| 31                  | 306               |
| 32                  | 180               |
| 33                  | 319               |
| 34                  | 188               |
| 35                  | 111               |
| 36                  | 230               |
| 37                  | 67                |
| 38                  | 280               |
| 39                  | 99                |
| 40                  | 334               |
| 41                  | 168               |

N----835

Table II (a) True-False Section of Geometry Test (Form A)  
 Rank of elements in order of difficulty according to  
 number of correct responses.

| Rank | Correst<br>responses | No. of test<br>element | Rank | Correct<br>responses | No. of test<br>element |
|------|----------------------|------------------------|------|----------------------|------------------------|
| 1    | 801                  | 1                      | 47   | 349                  | 22                     |
| 2    | 778                  | 8                      | 48   | 339                  | 56                     |
| 3    | 772                  | 44                     | 49   | 332                  | 57                     |
| 4    | 749                  | 37                     | 50   | 325                  | 66                     |
| 5    | 729                  | 38                     | 51   | 320                  | 23                     |
| 6    | 678                  | 16                     | 52   | 311                  | 4                      |
| 7    | 664                  | 26                     | 53   | 304                  | 83                     |
| 8    | 578                  | 59                     | 54   | 300                  | 72                     |
| 9    | 571                  | 46                     | 55   | 297                  | 60                     |
| 10   | 567                  | 28                     | 56   | 295                  | 41                     |
| 11   | 563                  | 15-6                   | 57   | 289                  | 82                     |
| 12   | 558                  | 53                     | 58   | 288                  | 70                     |
| 13   | 543                  | 55                     | 59   | 269                  | 73                     |
| 14   | 536                  | 2-18                   | 60   | 268                  | 34                     |
| 15   | 535                  | 5                      | 61   | 264                  | 75                     |
| 16   | 518                  | 33                     | 62   | 259                  | 76-58                  |
| 17   | 512                  | 47                     | 63   | 245                  | 7                      |
| 18   | 508                  | 12                     | 64   | 241                  | 52-78                  |
| 19   | 507                  | 25                     | 65   | 238                  | 90                     |
| 20   | 501                  | 40                     | 66   | 234                  | 61                     |
| 21   | 494                  | 63                     | 67   | 233                  | 81                     |
| 22   | 492                  | 32                     | 68   | 232                  | 86                     |
| 23   | 488                  | 35                     | 69   | 228                  | 77                     |
| 24   | 482                  | 31                     | 70   | 225                  | 80                     |
| 25   | 472                  | 42                     | 71   | 224                  | 39                     |
| 26   | 468                  | 29                     | 72   | 221                  | 45                     |
| 27   | 456                  | 43                     | 73   | 219                  | 62                     |
| 28   | 451                  | 50                     | 74   | 210                  | 89                     |
| 29   | 450                  | 19                     | 75   | 207                  | 11                     |
| 30   | 445                  | 64                     | 76   | 202                  | 85                     |
| 31   | 444                  | 71                     | 77   | 185                  | 84                     |
| 32   | 430                  | 9                      | 78   | 176                  | 30                     |
| 33   | 427                  | 10                     | 79   | 163                  | 65                     |
| 34   | 425                  | 21                     | 80   | 156                  | 49                     |
| 35   | 412                  | 17                     | 81   | 154                  | 48                     |
| 36   | 411                  | 20                     | 82   | 146                  | 74                     |
| 37   | 409                  | 24                     | 83   | 137                  | 88                     |
| 38   | 406                  | 69                     | 84   | 131                  | 79                     |
| 39   | 402                  | 36-68                  | 85   | 77                   | 87                     |
| 40   | 400                  | 13                     |      |                      |                        |
| 41   | 399                  | 54                     |      |                      |                        |
| 42   | 394                  | 3                      |      |                      |                        |
| 43   | 385                  | 67                     |      |                      |                        |
| 44   | 378                  | 14                     |      |                      |                        |
| 45   | 356                  | 27                     |      |                      |                        |
| 46   | 352                  | 51                     |      |                      |                        |

Table II (b) Problem Section of Geometry Test (Form A).  
Rank of elements in order of difficulty according to  
number of correct responses.

| Rank | Correct responses | No. of elements in Form A |
|------|-------------------|---------------------------|
| 1    | 790               | 1                         |
| 2    | 633               | 2                         |
| 3    | 592               | 21                        |
| 4    | 569               | 9                         |
| 5    | 548               | 10                        |
| 6    | 536               | 5                         |
| 7    | 523               | 22                        |
| 8    | 513               | 3                         |
| 9    | 495               | 24                        |
| 10   | 487               | 27                        |
| 11   | 476               | 29                        |
| 12   | 443               | 28                        |
| 13   | 419               | 23                        |
| 14   | 382               | 19                        |
| 15   | 378               | 14                        |
| 16   | 377               | 8                         |
| 17   | 350               | 26                        |
| 18   | 221               | 30                        |
| 19   | 199               | 18                        |
| 20   | 183               | 7                         |
| 21   | 179               | 4                         |
| 22   | 173               | 12                        |
| 23   | 170               | 20                        |
| 24   | 160               | 15                        |
| 25   | 156               | 6                         |
| 26   | 138               | 40                        |
| 27   | 123               | 36                        |
| 28   | 102               | 11-17                     |
| 29   | 55                | 34                        |
| 30   | 50                | 35-38                     |
| 31   | 47                | 33                        |
| 32   | 41                | 25                        |
| 33   | 40                | 16                        |
| 34   | 34                | 42                        |
| 35   | 33                | 32                        |
| 36   | 29                | 41                        |
| 37   | 26                | 39                        |
| 38   | 23                | 13-37                     |
| 39   | 19                | 31                        |
| 40   | 3                 | 44                        |
| 41   | 1                 | 43-45                     |

Table II (c) Logical Selection of Geometry Test (Form A).  
Rank of elements in order of difficulty to number of  
correct responses.

| Rank | Correct responses | No. of elements in Form A. |
|------|-------------------|----------------------------|
| 1    | 682               | 1                          |
| 2    | 664               | 2                          |
| 3    | 581               | 30                         |
| 4    | 552               | 14                         |
| 5    | 544               | 3                          |
| 6    | 476               | 11                         |
| 7    | 465               | 33                         |
| 8    | 464               | 31                         |
| 9    | 462               | 29                         |
| 10   | 455               | 15                         |
| 11   | 432               | 7                          |
| 12   | 370               | 10                         |
| 13   | 357               | 20                         |
| 14   | 332               | 34                         |
| 15   | 320               | 35                         |
| 16   | 314               | 13                         |
| 17   | 311               | 23                         |
| 18   | 298               | 5                          |
| 19   | 288               | 22                         |
| 20   | 284               | 18                         |
| 21   | 255               | 19                         |
| 22   | 244               | 17                         |
| 23   | 238               | 16                         |
| 24   | 232               | 12                         |
| 25   | 231               | 28                         |
| 26   | 222               | 36                         |
| 27   | 217               | 38                         |
| 28   | 205               | 32                         |
| 29   | 196               | 9                          |
| 30   | 173               | 40                         |
| 31   | 167               | 24                         |
| 32   | 163               | 21                         |
| 33   | 159               | 8                          |
| 34   | 157               | 27                         |
| 35   | 148               | 37                         |
| 36   | 133               | 4                          |
| 37   | 117               | 26                         |
| 38   | 115               | 41                         |
| 39   | 111               | 25                         |
| 40   | 99                | 6                          |
| 41   | 84                | 42                         |
| 42   | 27                | 39                         |

Table II (d) True-False Section of Geometry Test (Form B)  
 Rank of elements in order of difficulty according to  
 number of correct responses.

| Rank | Correct responses | No. of test element | Rank | Correct responses | No. of test element |
|------|-------------------|---------------------|------|-------------------|---------------------|
| 1    | 791               | 1                   | 45   | 340               | 29                  |
| 2    | 743               | 3                   | 46   | 328               | 50                  |
| 3    | 742               | 6                   | 47   | 317               | 72                  |
| 4    | 725               | 39                  | 48   | 316               | 73-43               |
| 5    | 691               | 27                  | 49   | 314               | 36-26               |
| 6    | 656               | 5                   | 50   | 311               | 70                  |
| 7    | 652               | 2                   | 51   | 304               | 63                  |
| 8    | 632               | 22                  | 52   | 292               | 85                  |
| 9    | 627               | 12-44               | 53   | 285               | 42                  |
| 10   | 604               | 64                  | 54   | 284               | 55                  |
| 11   | 593               | 13                  | 55   | 278               | 83                  |
| 12   | 592               | 40                  | 56   | 276               | 88                  |
| 13   | 583               | 7-48                | 57   | 272               | 60                  |
| 14   | 573               | 46                  | 58   | 264               | 67                  |
| 15   | 568               | 65                  | 59   | 253               | 81                  |
| 16   | 559               | 25                  | 60   | 241               | 79-41               |
| 17   | 525               | 35                  | 61   | 238               | 68                  |
| 18   | 524               | 20                  | 62   | 236               | 84                  |
| 19   | 511               | 31                  | 63   | 230               | 33                  |
| 20   | 509               | 37                  | 64   | 226               | 74-76               |
| 21   | 501               | 51                  | 65   | 225               | 78                  |
| 22   | 496               | 52                  | 66   | 218               | 45                  |
| 23   | 490               | 4                   | 67   | 214               | 53                  |
| 24   | 487               | 71                  | 68   | 208               | 9                   |
| 25   | 483               | 38                  | 69   | 201               | 66                  |
| 26   | 482               | 30                  | 70   | 200               | 80                  |
| 27   | 479               | 28                  | 71   | 195               | 75                  |
| 28   | 468               | 54                  | 72   | 194               | 86                  |
| 29   | 460               | 11                  | 73   | 191               | 59                  |
| 30   | 454               | 15                  | 74   | 186               | 82                  |
| 31   | 451               | 49                  | 75   | 178               | 62                  |
| 32   | 450               | 21                  | 76   | 160               | 57                  |
| 33   | 442               | 69-18               | 77   | 159               | 61                  |
| 34   | 430               | 56-16               | 78   | 148               | 8                   |
| 35   | 408               | 24                  | 79   | 121               | 89                  |
| 36   | 406               | 14                  | 80   | 120               | 90                  |
| 37   | 401               | 32                  | 81   | 89                | 87                  |
| 38   | 396               | 17                  | 82   | 70                | 77                  |
| 39   | 383               | 34                  |      |                   |                     |
| 40   | 367               | 58                  |      |                   |                     |
| 41   | 362               | 23                  |      |                   |                     |
| 42   | 357               | 47                  |      |                   |                     |
| 43   | 351               | 19                  |      |                   |                     |
| 44   | 345               | 10                  |      |                   |                     |

Table II (e) Problem Section of Geometry Test (Form B).  
 Rank of elements in order of difficulty according to  
 number of correct responses.

| Rank | Correct responses | No. of elements in Form B. |
|------|-------------------|----------------------------|
| 1    | 815               | 1                          |
| 2    | 711               | 2                          |
| 3    | 530               | 32                         |
| 4    | 492               | 8                          |
| 5    | 459               | 29                         |
| 6    | 382               | 25                         |
| 7    | 353               | 30                         |
| 8    | 352               | 28                         |
| 9    | 315               | 31                         |
| 10   | 269               | 3                          |
| 11   | 200               | 7                          |
| 12   | 198               | 19                         |
| 13   | 188               | 16                         |
| 14   | 168               | 6-12                       |
| 15   | 148               | 26                         |
| 16   | 137               | 23                         |
| 17   | 109               | 14                         |
| 18   | 94                | 40                         |
| 19   | 93                | 4                          |
| 20   | 85                | 10                         |
| 21   | 81                | 33                         |
| 22   | 80                | 15                         |
| 23   | 71                | 20                         |
| 24   | 64                | 41                         |
| 25   | 61                | 5                          |
| 26   | 58                | 36                         |
| 27   | 52                | 9-17                       |
| 28   | 40                | 34                         |
| 29   | 39                | 13                         |
| 30   | 36                | 24                         |
| 31   | 35                | 39                         |
| 32   | 34                | 43                         |
| 33   | 27                | 21                         |
| 34   | 24                | 35                         |
| 35   | 23                | 27-37-42                   |
| 36   | 22                | 11                         |
| 37   | 21                | 18                         |
| 38   | 17                | 38                         |
| 39   | 14                | 22                         |

Table II (f) Logical Selection of Geometry test (Form B)  
Rank of elements in order of difficulty according to  
number of correct responses.

| Rank | Correct responses | No. of elements in Form B |
|------|-------------------|---------------------------|
| 1    | 788               | 1                         |
| 2    | 682               | 18                        |
| 3    | 666               | 20                        |
| 4    | 640               | 2                         |
| 5    | 562               | 5                         |
| 6    | 518               | 14                        |
| 7    | 446               | 7                         |
| 8    | 390               | 4                         |
| 9    | 377               | 25                        |
| 10   | 373               | 16                        |
| 11   | 348               | 12                        |
| 12   | 347               | 27                        |
| 13   | 334               | 10-40                     |
| 14   | 319               | 33                        |
| 15   | 317               | 3                         |
| 16   | 310               | 15                        |
| 17   | 306               | 31                        |
| 18   | 301               | 30                        |
| 19   | 284               | 23                        |
| 20   | 280               | 38                        |
| 21   | 271               | 29                        |
| 22   | 266               | 26                        |
| 23   | 255               | 11                        |
| 24   | 241               | 9                         |
| 25   | 230               | 36                        |
| 26   | 216               | 6                         |
| 27   | 193               | 8                         |
| 28   | 188               | 34                        |
| 29   | 180               | 32                        |
| 30   | 170               | 17                        |
| 31   | 168               | 41                        |
| 32   | 161               | 21                        |
| 33   | 157               | 19                        |
| 34   | 120               | 28                        |
| 35   | 111               | 35                        |
| 36   | 110               | 13                        |
| 37   | 101               | 22-24                     |
| 38   | 99                | 39                        |
| 39   | 67                | 37                        |

Table III (a) Analysis of test results on elements in the True-False Section of Geometry Test.

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| 801                      | A             | 1  | omit  |
| 791                      | B             | 1  | omit  |
| 778                      | A             | 8  | omit  |
| 772                      | A             | 44                                       | A-1   |
| 749                      | A             | 37                                       | B-1   |
| 743                      | B             | 3  | B-2   |
| 742                      | B             | 6  | A-2   |
| 729                      | A             | 38                                       | omit  |
| 725                      | B             | 39                                       | A-3   |
| 691                      | B             | 27                                       | B-3   |
| 678                      | A             | 16                                       | B-4   |
| 664                      | A             | 26                                       | A-4   |
| 656                      | B             | 5  | A-5   |
| 652                      | B             | 2  | B-5   |
| 632                      | B             | 22                                       | omit  |
| 627                      | B             | 12                                       | B-6   |
| 627                      | A             | 44                                       | omit  |
| 604                      | B             | 64                                       | A-6   |
| 593                      | B             | 13                                       | A-7   |
| 592                      | B             | 40                                       | B-7   |
| 583                      | B             | 7  | B-8   |
| 583                      | A             | 48                                       | A-8   |
| 578                      | A             | 59                                       | A-9   |
| 573                      | B             | 46                                       | B-9   |
| 571                      | A             | 46                                       | B-10  |
| 568                      | B             | 65                                       | omit  |
| 567                      | A             | 28                                       | A-10  |
| 563                      | A             | 15                                       | omit  |
| 563                      | B             | 6  | omit  |
| 559                      | B             | 25                                       | A-11  |
| 558                      | A             | 53                                       | B-11  |
| 543                      | A             | 55                                       | B-12  |
| 536                      | A             | 2  | A-12  |
| 536                      | B             | 18                                       | A-13  |
| 535                      | A             | 5  | B-13  |
| 525                      | B             | 35                                       | B-14  |
| 524                      | B             | 20                                       | A-14  |
| 518                      | A             | 33                                       | A-15  |
| 512                      | A             | 47                                       | B-15  |
| 511                      | B             | 31                                       | B-16  |
| 509                      | B             | 37                                       | A-16  |
| 508                      | A             | 12                                       | A-17  |
| 507                      | A             | 25                                       | B-17  |
| 501                      | A             | 40                                       | B-18  |

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| <del>501-801</del>       | B             | 51                                       | A-18  |
| 496                      | B             | 52                                       | A-19  |
| 494                      | A             | 63                                       | B-19  |
| 492                      | A             | 32                                       | B-20  |
| 490                      | B             | 4  | omit  |
| 488                      | A             | 35                                       | A-50 20   |
| 487                      | B             | 71                                       | A-21  |
| 483                      | B             | 38                                       | B-21  |
| 482                      | A             | 31                                       | B-22  |
| 482                      | B             | 30                                       | A-22  |
| 479                      | B             | 28                                       | A-23  |
| 472                      | A             | 42                                       | B-24  |
| 468                      | A             | 29                                       | B-25  |
| 468                      | B             | 54                                       | omit  |
| 460                      | B             | 11                                       | A-25  |
| 456                      | A             | 43                                       | A-25  |
| 454                      | B             | 15                                       | omit  |
| 451                      | A             | 50                                       | omit  |
| 451                      | B             | 47                                       | omit  |
| 450                      | A             | 19                                       | omit  |
| 450                      | B             | 21                                       | omit  |
| 445                      | A             | 64                                       | B-26  |
| 444                      | A             | 71                                       | B-27  |
| 442                      | B             | 69                                       | A-27  |
| 442                      | B             | 18                                       | omit  |
| 430                      | A             | 9  | A-28  |
| 430                      | B             | 16                                       | B-28  |
| 427                      | A             | 10                                       | B-29  |
| 425                      | A             | 21                                       | A-29  |
| 412                      | A             | 17                                       | A-30  |
| 411                      | A             | 20                                       | B-30  |
| 409                      | A             | 24                                       | B-31  |
| 408                      | B             | 24                                       | A-31  |
| 406                      | A             | 69                                       | A-32  |
| 406                      | B             | 18                                       | omit  |
| 402                      | A             | 36                                       | B-32  |
| 402                      | A             | 68                                       | B-33  |
| 401                      | B             | 32                                       | A-33  |
| 400                      | A             | 13                                       | A-34  |
| 399                      | A             | 54                                       | B-34  |
| 396                      | B             | 17                                       | B-35  |
| 394                      | A             | 3  | A-35  |
| 385                      | A             | 67                                       | A-36  |
| 383                      | B             | 34                                       | B-37  |
| 378                      | A             | 14                                       | B-38  |
| 367                      | B             | 58                                       | A-37  |

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| 362                      | B             | 23                                       | A-38  |
| 357                      | B             | 47                                       | omit  |
| 356                      | A             | 27                                       | B-39  |
| 352                      | A             | 51                                       | omit  |
| 351                      | B             | 19                                       | omit  |
| 349                      | A             | 22                                       | B-40  |
| 345                      | B             | 10                                       | omit  |
| 340                      | B             | 29                                       | A-39  |
| 339                      | A             | 56                                       | A-40  |
| 332                      | A             | 57                                       | B-41  |
| 328                      | B             | 50                                       | B-42  |
| 325                      | A             | 66                                       | A-41  |
| 320                      | A             | 23                                       | A-42  |
| 317                      | B             | 72                                       | omit  |
| 316                      | B             | 73                                       | B-43  |
| 314                      | B             | 36                                       | A-43  |
| 311                      | A             | 4  | A-44  |
| 311                      | B             | 70                                       | B-44  |
| 304                      | A             | 83                                       | B-45  |
| 304                      | B             | 63                                       | omit  |
| 300                      | A             | 72                                       | A-45  |
| 297                      | A             | 60                                       | A-46  |
| 295                      | A             | 41                                       | B-46  |
| 292                      | B             | 85                                       | omit  |
| 289                      | A             | 82                                       | B-47  |
| 288                      | A             | 70                                       | A-47  |
| 285                      | B             | 42                                       | A-48  |
| 284                      | B             | 55                                       | B-48  |
| 278                      | B             | 83                                       | B-49  |
| 276                      | B             | 88                                       | A-49  |
| 272                      | B             | 60                                       | A-50  |
| 269                      | A             | 73                                       | B-50  |
| 268                      | A             | 34                                       | B-51  |
| 264                      | A             | 75                                       | A-51  |
| 264                      | B             | 67                                       | A-52  |
| 259                      | A             | 76                                       | B-52  |
| 259                      | A             | 58                                       | omit  |
| 253                      | B             | 81                                       | B-53  |
| 245                      | A             | 7  | omit  |
| 241                      | A             | 79                                       | A-53  |
| 241                      | B             | 41                                       | A-54  |
| 238                      | A             | 90                                       | B-54  |
| 238                      | B             | 68                                       | B-55  |
| 236                      | B             | 84                                       | A-55  |
| 234                      | A             | 61                                       | A-56  |
| 233                      | A             | 81                                       | B-56  |

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| 232                      | A             | 86                                       | B-57  |
| 230                      | B             | 33                                       | A-57  |
| 228                      | A             | 77                                       | A-58  |
| 226                      | B             | 74                                       | B-58  |
| 226                      | B             | 76                                       | B-59  |
| 225                      | A             | 80                                       | omit  |
| 225                      | B             | 78                                       | A-59  |
| 224                      | A             | 39                                       | A-60  |
| 221                      | A             | 45                                       | B-60  |
| 219                      | A             | 62                                       | B-61  |
| 218                      | B             | 45                                       | A-61  |
| 214                      | B             | 53                                       | A-62  |
| 210                      | A             | 89                                       | omit  |
| 208                      | B             | 9  | B-62  |
| 207                      | A             | 11                                       | B-63  |
| 202                      | A             | 85                                       | A-63  |
| 201                      | B             | 66                                       | A-64  |
| 200                      | B             | 80                                       | B-64  |
| 195                      | B             | 75                                       | B-65  |
| 194                      | B             | 86                                       | omit  |
| 191                      | B             | 59                                       | A-65  |
| 186                      | B             | 82                                       | A-66  |
| 185                      | A             | 84                                       | B-66  |
| 178                      | B             | 62                                       | B-67  |
| 176                      | A             | 30                                       | A-67  |
| 163                      | A             | 65                                       | A-68  |
| 160                      | B             | 57                                       | B-68  |
| 159                      | B             | 61                                       | B-69  |
| 156                      | A             | 49                                       | A-69  |
| 154                      | A             | 48                                       | A-70  |
| 148                      | B             | 8  | B-70  |
| 146                      | A             | 74                                       | B-71  |
| 137                      | A             | 88                                       | A-71  |
| 131                      | A             | 79                                       | A-72  |
| 121                      | B             | 89                                       | B-72  |
| 120                      | B             | 90                                       | omit  |
| 89                       | B             | 87                                       | B-73  |
| 77                       | A             | 87                                       | A-73  |
| 70                       | B             | 77                                       | A-74  |

Table III (b) Analysis of test results on elements in the True-False Section of Geometry Test.

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| 788                      | B             | 11                                       | omit  |
| 682                      | A             | 1  | A-1   |
| 682                      | B             | 18                                       | B-1   |
| 666                      | B             | 20                                       | B-2   |
| 664                      | A             | 2  | A-2   |
| 640                      | B             | 2  | A-3   |
| 581                      | A             | 30                                       | B-3   |
| 562                      | B             | 5  | B-4   |
| 552                      | A             | 14                                       | A-4   |
| 544                      | A             | 3  | omit  |
| 518                      | B             | 14                                       | A-5   |
| 476                      | A             | 11                                       | B-5   |
| 465                      | A             | 33                                       | B-6   |
| 464                      | A             | 31                                       | A-6   |
| 462                      | A             | 29                                       | A-7   |
| 455                      | A             | 15                                       | B-7   |
| 446                      | B             | 7  | B-8   |
| 432                      | A             | 7  | A-8   |
| 390                      | B             | 4  | A-9   |
| 377                      | B             | 25                                       | B-9   |
| 373                      | B             | 16                                       | B-10  |
| 370                      | A             | 10                                       | A-10  |
| 357                      | A             | 20                                       | A-11  |
| 342                      | B             | 12                                       | B-11  |
| 347                      | B             | 27                                       | B-12  |
| 334                      | B             | 10                                       | A-12  |
| 334                      | B             | 40                                       | A-13  |
| 332                      | A             | 34                                       | B-13  |
| 320                      | A             | 35                                       | B-14  |
| 319                      | B             | 33                                       | A-14  |
| 317                      | B             | 3  | A-15  |
| 314                      | A             | 13                                       | omit  |
| 311                      | A             | 23                                       | omit  |
| 310                      | B             | 15                                       | B-15  |
| 306                      | B             | 31                                       | B-16  |
| 301                      | B             | 30                                       | A-16  |
| 298                      | A             | 5  | A-17  |
| 288                      | A             | 22                                       | B-17  |
| 284                      | A             | 18                                       | B-18  |
| 284                      | B             | 23                                       | A-18  |
| 280                      | B             | 38                                       | A-19  |
| 271                      | B             | 29                                       | B-19  |
| 266                      | B             | 26                                       | B-20  |
| 255                      | A             | 19                                       | A-20  |
| 255                      | B             | 11                                       | B-21  |

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| 244                      | A             | 17                                       | A-21  |
| 241                      | B             | 9  | B-22  |
| 238                      | A             | 16                                       | A-22  |
| 232                      | A             | 12                                       | omit  |
| 231                      | A             | 28                                       | A-23  |
| 230                      | B             | 16                                       | omit  |
| 222                      | A             | 36                                       | B-23  |
| 217                      | A             | 38                                       | B-24  |
| 216                      | B             | 6  | omit  |
| 196                      | A             | 9  | A-24  |
| 193                      | B             | 8  | A-25  |
| 188                      | B             | 34                                       | B-25  |
| 180                      | B             | 32                                       | B-26  |
| 173                      | A             | 40                                       | A-26  |
| 170                      | B             | 17                                       | A-27  |
| 168                      | B             | 41                                       | B-27  |
| 167                      | A             | 24                                       | B-28  |
| 163                      | A             | 21                                       | A-28  |
| 161                      | B             | 21                                       | A-29  |
| 159                      | A             | 8  | B-29  |
| 157                      | A             | 27                                       | B-30  |
| 157                      | B             | 19                                       | A-30  |
| 148                      | A             | 37                                       | A-31  |
| 133                      | A             | 4  | omit  |
| 120                      | B             | 28                                       | B-31  |
| 117                      | A             | 26                                       | B-32  |
| 115                      | A             | 41                                       | A-32  |
| 111                      | A             | 25                                       | omit  |
| 111                      | B             | 35                                       | omit  |
| 110                      | B             | 13                                       | A-33  |
| 101                      | B             | 22                                       | B-33  |
| 101                      | B             | 24                                       | B-34  |
| 99                       | A             | 6  | A-34  |
| 99                       | B             | 39                                       | A-35  |
| 84                       | A             | 42                                       | omit  |
| 67                       | B             | 37                                       | omit  |
| 27                       | A             | 39                                       | B-35  |

Table III (c) Analysis of test results on elements in the Problem Section of Geometry Test.

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of Test |
|--------------------------|---------------|--|---|
| 815                      | B             | 1  | A-1   |
| 790                      | A             | 1  | B-1   |
| 711                      | B             | 2  | B-2   |
| 592                      | A             | 21                                       | A-2   |
| 569                      | A             | 9  | A-3   |
| 548                      | A             | 10                                       | B-3   |
| 536                      | A             | 5  | B-4   |
| 530                      | B             | 32                                       | A-4   |
| 523                      | A             | 22                                       | A-5   |
| 513                      | A             | 23                                       | B-5   |
| 495                      | A             | 24                                       | B-6   |
| 492                      | B             | 8  | A-6   |
| 487                      | A             | 27                                       | omit  |
| 476                      | A             | 29                                       | A-7   |
| 443                      | A             | 28                                       | B-7   |
| 419                      | A             | 23                                       | B-8   |
| 382                      | A             | 19                                       | A-8   |
| 382                      | B             | 25                                       | omit  |
| 378                      | A             | 14                                       | A-9   |
| 377                      | A             | 8  | omit  |
| 353                      | B             | 30                                       | B-9   |
| 352                      | B             | 28                                       | B-10  |
| 350                      | A             | 26                                       | omit  |
| 315                      | B             | 31                                       | A-10  |
| 269                      | B             | 3  | A-11  |
| 221                      | A             | 30                                       | B-11  |
| 200                      | B             | 7  | B-12  |
| 199                      | A             | 18                                       | A-12  |
| 198                      | B             | 19                                       | omit  |
| 188                      | B             | 16                                       | A-13  |
| 183                      | A             | 7  | B-13  |
| 179                      | A             | 4  | B-14  |
| 173                      | A             | 12                                       | omit  |
| 170                      | A             | 20                                       | A-14  |
| 168                      | B             | 6  | A-15  |
| 168                      | B             | 12                                       | B-15  |
| 160                      | A             | 15                                       | B-16  |
| 156                      | A             | 6  | A-16  |
| 148                      | B             | 26                                       | omit  |
| 138                      | A             | 40                                       | A-17  |
| 137                      | B             | 23                                       | B-17  |
| 123                      | A             | 36                                       | B-18  |
| 109                      | B             | 14                                       | A-18  |

| No. of correct responses | Original Form | No. of the test element in Original Form | Elements omitted or ranked in New Forms of test |
|--------------------------|---------------|--|---|
| 102                      | A             | 11                                       | A-19  |
| 102                      | A             | 17                                       | omit  |
| 94                       | B             | 19                                       | B-19  |
| 93                       | B             | 4  | omit  |
| 85                       | B             | 10                                       | omit  |
| 81                       | B             | 33                                       | B-20  |
| 80                       | B             | 15                                       | A-20  |
| 71                       | B             | 20                                       | omit  |
| 64                       | B             | 41                                       | omit  |
| 61                       | B             | 5  | omit  |
| 58                       | B             | 36                                       | A-21  |
| 55                       | A             | 34                                       | omit  |
| 52                       | B             | 9  | B-21  |
| 52                       | B             | 17                                       | B-22  |
| 50                       | A             | 35                                       | A-22  |
| 50                       | A             | 38                                       | omit  |
| 47                       | A             | 33                                       | B-23  |
| 41                       | A             | 25                                       | B-24  |
| 40                       | A             | 16                                       | A-24  |
| 40                       | B             | 34                                       | omit  |
| 39                       | B             | 13                                       | A-25  |
| 36                       | B             | 24                                       | omit  |
| 35                       | B             | 39                                       | B-25  |
| 34                       | A             | 42                                       | B-26  |
| 34                       | B             | 43                                       | A-26  |
| 33                       | A             | 32                                       | A-27  |
| 29                       | A             | 41                                       | omit  |
| 26                       | B             | 35                                       | omit  |
| 24                       | A             | 39                                       | B-27  |
| 23                       | A             | 13                                       | B-28  |
| 23                       | B             | 37                                       | omit  |
| 22                       | B             | 27                                       | A-28  |
| 22                       | B             | 37                                       | omit  |
| 22                       | B             | 42                                       | A-29  |
| 21                       | B             | 11                                       | B-29  |
| 19                       | A             | 18                                       | omit  |
| 17                       | B             | 31                                       | A-30  |
| 14                       | B             | 22                                       | omit  |
| 3                        | A             | 44                                       | omit  |
| 1                        | A             | 43                                       | B-30  |
| 1                        | A             | 45                                       | omit  |

Table IV (a) True-False Section of Geometry Test (Form A). Success of each element of the test by the "Good Group" consisting of one hundred students whose gross scores were highest, and by the "Poor Group" Consisting of one hundred students whose gross scores were lowest.

| No. of test element | Success in Good Group | Success in Poor Group |
|---------------------|-----------------------|-----------------------|
| 1                   | 100                   | 100                   |
| 2                   | 84                    | 57                    |
| 3                   | 71                    | 29                    |
| 4                   | 64                    | 26                    |
| 5                   | 88                    | 55                    |
| 6                   | 87                    | 36                    |
| 7                   | 22                    | 24                    |
| 8                   | 99                    | 93                    |
| 9                   | 77                    | 25                    |
| 10                  | 77                    | 45                    |
| 11                  | 48                    | 14                    |
| 12                  | 84                    | 38                    |
| 13                  | 52                    | 37                    |
| 14                  | 87                    | 19                    |
| 15                  | 80                    | 47                    |
| 16                  | 92                    | 70                    |
| 17                  | 72                    | 37                    |
| 18                  | 87                    | 51                    |
| 19                  | 70                    | 49                    |
| 20                  | 73                    | 33                    |
| 21                  | 64                    | 30                    |
| 22                  | 72                    | 18                    |
| 23                  | 57                    | 23                    |
| 24                  | 54                    | 49                    |
| 25                  | 82                    | 46                    |
| 26                  | 97                    | 60                    |
| 27                  | 63                    | 15                    |
| 28                  | 89                    | 44                    |
| 29                  | 80                    | 55                    |
| 30                  | 35                    | 9                     |
| 31                  | 80                    | 42                    |
| 32                  | 90                    | 25                    |
| 33                  | 79                    | 47                    |
| 34                  | 51                    | 22                    |
| 35                  | 80                    | 39                    |
| 36                  | 70                    | 30                    |
| 37                  | 93                    | 47                    |
| 38                  | 96                    | 90                    |
| 39                  | 40                    | 17                    |
| 40                  | 72                    | 49                    |
| 41                  | 66                    | 15                    |
| 42                  | 94                    | 25                    |

| No. of test element | Success in Good Group | Success in Poor Group |
|---------------------|-----------------------|-----------------------|
| 43                  | 72                    | 33                    |
| 44                  | 100                   | 84                    |
| 45                  | 46                    | 14                    |
| 46                  | 85                    | 47                    |
| 47                  | 92                    | 23                    |
| 48                  | 41                    | 8                     |
| 49                  | 40                    | 7                     |
| 50                  | 88                    | 23                    |
| 51                  | 65                    | 21                    |
| 52                  | 54                    | 6                     |
| 53                  | 94                    | 22                    |
| 54                  | 87                    | 22                    |
| 55                  | 97                    | 42                    |
| 56                  | 59                    | 24                    |
| 57                  | 47                    | 22                    |
| 58                  | 43                    | 16                    |
| 59                  | 93                    | 27                    |
| 60                  | 68                    | 4                     |
| 61                  | 66                    | 9                     |
| 62                  | 37                    | 6                     |
| 63                  | 82                    | 25                    |
| 64                  | 80                    | 19                    |
| 65                  | 35                    | 0                     |
| 66                  | 71                    | 6                     |
| 67                  | 69                    | 19                    |
| 68                  | 68                    | 13                    |
| 69                  | 80                    | 10                    |
| 70                  | 54                    | 10                    |
| 71                  | 85                    | 31                    |
| 72                  | 75                    | 11                    |
| 73                  | 67                    | 8                     |
| 74                  | 44                    | 2                     |
| 75                  | 70                    | 10                    |
| 76                  | 66                    | 5                     |
| 77                  | 57                    | 8                     |
| 78                  | 55                    | 8                     |
| 79                  | 39                    | 2                     |
| 80                  | 67                    | 9                     |
| 81                  | 71                    | 7                     |
| 82                  | 69                    | 13                    |
| 83                  | 67                    | 18                    |
| 84                  | 53                    | 3                     |
| 85                  | 45                    | 11                    |
| 86                  | 59                    | 8                     |
| 87                  | 32                    | 0                     |
| 88                  | 34                    | 4                     |
| 89                  | 59                    | 2                     |
| 90                  | 56                    | 8                     |

Table IV (b) True-False Section of Geometry Test (Form A)  
Success of each element of the test by the "Good Group"  
consisting of one hundred students whose gross scores were  
highest, and by the "Poor Group" consisting of one hundred  
students whose gross scores were lowest.

| No. of test<br>element | Success in<br>Good Group | Success in<br>Poor Group |
|------------------------|--------------------------|--------------------------|
| 1                      | 101                      | 86                       |
| 2                      | 98                       | 50                       |
| 3                      | 91                       | 29                       |
| 4                      | 42                       | 7                        |
| 5                      | 85                       | 25                       |
| 6                      | 32                       | 2                        |
| 7                      | 56                       | 6                        |
| 8                      | 80                       | 11                       |
| 9                      | 93                       | 37                       |
| 10                     | 86                       | 40                       |
| 11                     | 35                       | 4                        |
| 12                     | 56                       | 4                        |
| 13                     | 6                        | 0                        |
| 14                     | 77                       | 13                       |
| 15                     | 50                       | 7                        |
| 16                     | 10                       | 4                        |
| 17                     | 38                       | 3                        |
| 18                     | 55                       | 2                        |
| 19                     | 91                       | 5                        |
| 20                     | 60                       | 5                        |
| 21                     | 98                       | 20                       |
| 22                     | 96                       | 11                       |
| 23                     | 82                       | 14                       |
| 24                     | 96                       | 11                       |
| 25                     | 17                       | 0                        |
| 26                     | 86                       | 6                        |
| 27                     | 101                      | 11                       |
| 28                     | 99                       | 8                        |
| 29                     | 99                       | 14                       |
| 30                     | 87                       | 1                        |
| 31                     | 11                       | 0                        |
| 32                     | 21                       | 1                        |
| 33                     | 25                       | 3                        |
| 34                     | 27                       | 0                        |
| 35                     | 25                       | 0                        |
| 36                     | 51                       | 1                        |
| 37                     | 11                       | 0                        |
| 38                     | 20                       | 4                        |
| 39                     | 14                       | 1                        |
| 40                     | 46                       | 4                        |
| 41                     | 18                       | 0                        |
| 42                     | 23                       | 0                        |
| 43                     | 1                        | 0                        |
| 44                     | 3                        | 0                        |
| 45                     | 1                        | 0                        |

Table IV (c) Logical Selection From A. Success of each element of the test by the "Good Group" consisting of one hundred students whose gross scores were highest, and by the "Poor Group" consisting of one hundred students whose gross scores were lowest.

| No. of test elements | Success in Good Group | Success in Poor Group |
|----------------------|-----------------------|-----------------------|
| 1                    | 93                    | 77                    |
| 2                    | 98                    | 75                    |
| 3                    | 92                    | 62                    |
| 4                    | 37                    | 11                    |
| 5                    | 75                    | 9                     |
| 6                    | 35                    | 4                     |
| 7                    | 76                    | 25                    |
| 8                    | 43                    | 9                     |
| 9                    | 49                    | 10                    |
| 10                   | 83                    | 20                    |
| 11                   | 89                    | 30                    |
| 12                   | 69                    | 15                    |
| 13                   | 70                    | 24                    |
| 14                   | 92                    | 47                    |
| 15                   | 85                    | 33                    |
| 16                   | 47                    | 17                    |
| 17                   | 53                    | 19                    |
| 18                   | 67                    | 17                    |
| 19                   | 62                    | 11                    |
| 20                   | 66                    | 18                    |
| 21                   | 36                    | 13                    |
| 22                   | 68                    | 10                    |
| 23                   | 75                    | 13                    |
| 24                   | 34                    | 7                     |
| 25                   | 31                    | 2                     |
| 26                   | 19                    | 6                     |
| 27                   | 44                    | 7                     |
| 28                   | 52                    | 11                    |
| 29                   | 85                    | 17                    |
| 30                   | 89                    | 33                    |
| 31                   | 87                    | 24                    |
| 32                   | 66                    | 4                     |
| 33                   | 91                    | 13                    |
| 34                   | 71                    | 5                     |
| 35                   | 73                    | 12                    |
| 36                   | 52                    | 4                     |
| 37                   | 38                    | 1                     |
| 38                   | 57                    | 6                     |
| 39                   | 8                     | 0                     |
| 40                   | 52                    | 5                     |
| 41                   | 36                    | 1                     |
| 42                   | 16                    | 5                     |

Table IV (d) True-False Section of Geometry Test Form B. Success of each element of the test by the "Good Group" consisting of one hundred students whose gross scores were highest, and by the "Poor Group" consisting of one hundred students whose gross scores were lowest.

| No. of test element | Success in Good Group | Success in Poor Group |
|---------------------|-----------------------|-----------------------|
| 1                   | 96                    | 98                    |
| 2                   | 95                    | 42                    |
| 3                   | 92                    | 89                    |
| 4                   | 86                    | 33                    |
| 5                   | 88                    | 61                    |
| 6                   | 99                    | 77                    |
| 7                   | 93                    | 55                    |
| 8                   | 31                    | 9                     |
| 9                   | 35                    | 17                    |
| 10                  | 64                    | 17                    |
| 11                  | 65                    | 46                    |
| 12                  | 90                    | 66                    |
| 13                  | 80                    | 46                    |
| 14                  | 53                    | 31                    |
| 15                  | 62                    | 47                    |
| 16                  | 68                    | 25                    |
| 17                  | 71                    | 13                    |
| 18                  | 62                    | 41                    |
| 19                  | 65                    | 11                    |
| 20                  | 74                    | 47                    |
| 21                  | 51                    | 39                    |
| 22                  | 81                    | 40                    |
| 23                  | 64                    | 18                    |
| 24                  | 81                    | 19                    |
| 25                  | 76                    | 53                    |
| 26                  | 53                    | 20                    |
| 27                  | 89                    | 65                    |
| 28                  | 73                    | 31                    |
| 29                  | 61                    | 17                    |
| 30                  | 75                    | 30                    |
| 31                  | 74                    | 31                    |
| 32                  | 67                    | 16                    |
| 33                  | 48                    | 3                     |
| 34                  | 66                    | 21                    |
| 35                  | 61                    | 47                    |
| 36                  | 71                    | 8                     |
| 37                  | 79                    | 23                    |
| 38                  | 80                    | 31                    |
| 39                  | 93                    | 62                    |
| 40                  | 91                    | 46                    |
| 41                  | 50                    | 13                    |
| 42                  | 54                    | 9                     |
| 43                  | 64                    | 10                    |
| 44                  | 84                    | 47                    |

| No. of test element | Success in Good Group | Success in Poor Group |
|---------------------|-----------------------|-----------------------|
| 45                  | 58                    | 5                     |
| 46                  | 85                    | 48                    |
| 47                  | 75                    | 9                     |
| 48                  | 78                    | 62                    |
| 49                  | 81                    | 20                    |
| 50                  | 71                    | 7                     |
| 51                  | 76                    | 32                    |
| 52                  | 81                    | 36                    |
| 53                  | 45                    | 1                     |
| 54                  | 82                    | 29                    |
| 55                  | 66                    | 9                     |
| 56                  | 65                    | 19                    |
| 57                  | 34                    | 11                    |
| 58                  | 40                    | 25                    |
| 59                  | 32                    | 11                    |
| 60                  | 55                    | 4                     |
| 61                  | 29                    | 3                     |
| 62                  | 31                    | 4                     |
| 63                  | 69                    | 7                     |
| 64                  | 94                    | 51                    |
| 65                  | 86                    | 40                    |
| 66                  | 36                    | 13                    |
| 67                  | 73                    | 3                     |
| 68                  | 58                    | 1                     |
| 69                  | 87                    | 26                    |
| 70                  | 57                    | 24                    |
| 71                  | 83                    | 24                    |
| 72                  | 78                    | 7                     |
| 73                  | 56                    | 13                    |
| 74                  | 64                    | 4                     |
| 75                  | 39                    | 13                    |
| 76                  | 60                    | 15                    |
| 77                  | 18                    | 5                     |
| 78                  | 23                    | 18                    |
| 79                  | 75                    | 4                     |
| 80                  | 62                    | 4                     |
| 81                  | 72                    | 5                     |
| 82                  | 39                    | 15                    |
| 83                  | 73                    | 15                    |
| 84                  | 74                    | 5                     |
| 85                  | 74                    | 18                    |
| 86                  | 63                    | 2                     |
| 87                  | 32                    | 1                     |
| 88                  | 81                    | 7                     |
| 89                  | 38                    | 4                     |
| 90                  | 50                    | 9                     |

Table IV (e) Problem Section of Geometry test Form A. Success of each element of the test by the "Good Group" consisting of one hundred students whose gross scores were highest, and by the "Poor Group" consisting of one hundred students whose gross scores were lowest.

| No. of test element | Success in Good Group | Success in Poor Group |
|---------------------|-----------------------|-----------------------|
| 1                   | 99                    | 83                    |
| 2                   | 94                    | 63                    |
| 3                   | 61                    | 5                     |
| 4                   | 49                    | 4                     |
| 5                   | 15                    | 2                     |
| 6                   | 47                    | 3                     |
| 7                   | 44                    | 5                     |
| 8                   | 93                    | 18                    |
| 9                   | 19                    | 3                     |
| 10                  | 34                    | 0                     |
| 11                  | 13                    | 0                     |
| 12                  | 49                    | 6                     |
| 13                  | 14                    | 1                     |
| 14                  | 27                    | 2                     |
| 15                  | 27                    | 0                     |
| 16                  | 47                    | 9                     |
| 17                  | 18                    | 0                     |
| 18                  | 4                     | 2                     |
| 19                  | 56                    | 2                     |
| 20                  | 21                    | 1                     |
| 21                  | 15                    | 0                     |
| 22                  | 4                     | 0                     |
| 23                  | 45                    | 0                     |
| 24                  | 18                    | 2                     |
| 25                  | 82                    | 12                    |
| 26                  | 45                    | 0                     |
| 27                  | 14                    | 0                     |
| 28                  | 78                    | 7                     |
| 29                  | 85                    | 10                    |
| 30                  | 76                    | 2                     |
| 31                  | 83                    | 2                     |
| 32                  | 88                    | 28                    |
| 33                  | 29                    | 1                     |
| 34                  | 18                    | 0                     |
| 35                  | 6                     | 1                     |
| 36                  | 30                    | 0                     |
| 37                  | 13                    | 0                     |
| 38                  | 9                     | 0                     |
| 39                  | 12                    | 1                     |
| 40                  | 23                    | 6                     |
| 41                  | 16                    | 0                     |
| 42                  | 9                     | 3                     |
| 43                  | 14                    | 1                     |

Table IV (f) Logical Selection Section of Geometry Test. Success of each element of the test by the "Good Group" consisting of one hundred students whose gross scores were highest, and by the "Poor Group" consisting of one hundred students whose gross scores were lowest.

| No. of test element | Success in Good Group | Success in Poor Group |
|---------------------|-----------------------|-----------------------|
| 1                   | 98                    | 82                    |
| 2                   | 95                    | 53                    |
| 3                   | 56                    | 21                    |
| 4                   | 65                    | 34                    |
| 5                   | 87                    | 45                    |
| 6                   | 45                    | 7                     |
| 7                   | 79                    | 19                    |
| 8                   | 50                    | 1                     |
| 9                   | 55                    | 17                    |
| 10                  | 70                    | 12                    |
| 11                  | 49                    | 18                    |
| 12                  | 67                    | 11                    |
| 13                  | 23                    | 4                     |
| 14                  | 81                    | 39                    |
| 15                  | 73                    | 11                    |
| 16                  | 72                    | 25                    |
| 17                  | 47                    | 2                     |
| 18                  | 93                    | 54                    |
| 19                  | 45                    | 6                     |
| 20                  | 89                    | 63                    |
| 21                  | 42                    | 3                     |
| 22                  | 29                    | 1                     |
| 23                  | 52                    | 15                    |
| 24                  | 29                    | 4                     |
| 25                  | 73                    | 18                    |
| 26                  | 70                    | 13                    |
| 27                  | 68                    | 22                    |
| 28                  | 22                    | 6                     |
| 29                  | 66                    | 11                    |
| 30                  | 63                    | 10                    |
| 31                  | 82                    | 11                    |
| 32                  | 32                    | 11                    |
| 33                  | 73                    | 15                    |
| 34                  | 42                    | 11                    |
| 35                  | 36                    | 3                     |
| 36                  | 53                    | 10                    |
| 37                  | 26                    | 0                     |
| 38                  | 72                    | 6                     |
| 39                  | 27                    | 3                     |
| 40                  | 67                    | 18                    |
| 41                  | 43                    | 5                     |

Table V (a) True-False Section of Geometry Test. The reckoning of the total number of correct responses on newly constructed test from correct responses each test element received in the original testing.

| Form A              |                   | Form B              |                   |
|---------------------|-------------------|---------------------|-------------------|
| No. of test element | Correct Responses | No. of test element | Correct responses |
| 1                   | 772               | 1                   | 749               |
| 2                   | 742               | 2                   | 743               |
| 3                   | 725               | 3                   | 691               |
| 4                   | 664               | 4                   | 678               |
| 5                   | 656               | 5                   | 652               |
| 6                   | 604               | 6                   | 627               |
| 7                   | 593               | 7                   | 592               |
| 8                   | 585               | 8                   | 583               |
| 9                   | 578               | 9                   | 573               |
| 10                  | 567               | 10                  | 571               |
| 11                  | 559               | 11                  | 558               |
| 12                  | 536               | 12                  | 543               |
| 13                  | 542               | 13                  | 535               |
| 14                  | 524               | 14                  | 525               |
| 15                  | 518               | 15                  | 512               |
| 16                  | 509               | 16                  | 511               |
| 17                  | 508               | 17                  | 507               |
| 18                  | 501               | 18                  | 501               |
| 19                  | 496               | 19                  | 494               |
| 20                  | 488               | 20                  | 492               |
| 21                  | 483               | 21                  | 487               |
| 22                  | 482               | 22                  | 482               |
| 23                  | 460               | 23                  | 479               |
| 24                  | 456               | 24                  | 472               |
| 25                  | 451               | 25                  | 468               |
| 26                  | 450               | 26                  | 445               |
| 27                  | 430               | 27                  | 444               |
| 28                  | 430               | 28                  | 442               |
| 29                  | 425               | 29                  | 430               |
| 30                  | 412               | 30                  | 427               |
| 31                  | 408               | 31                  | 411               |
| 32                  | 402               | 32                  | 409               |
| 33                  | 401               | 33                  | 406               |
| 34                  | 396               | 34                  | 402               |
| 35                  | 394               | 35                  | 400               |
| 36                  | 385               | 36                  | 399               |
| 37                  | 367               | 37                  | 383               |
| 38                  | 362               | 38                  | 378               |

| Form A              |                   | Form B               |                   |
|---------------------|-------------------|----------------------|-------------------|
| No. of test element | Correct Responses | No. of testt element | Correct Responses |
| 39                  | 339               | 39                   | 356               |
| 40                  | 332               | 40                   | 349               |
| 41                  | 325               | 41                   | 340               |
| 42                  | 320               | 42                   | 328               |
| 43                  | 314               | 43                   | 316               |
| 44                  | 311               | 44                   | 311               |
| 45                  | 300               | 45                   | 304               |
| 46                  | 297               | 46                   | 295               |
| 47                  | 288               | 47                   | 289               |
| 48                  | 285               | 48                   | 284               |
| 49                  | 276               | 49                   | 278               |
| 50                  | 272               | 50                   | 269               |
| 51                  | 264               | 51                   | 268               |
| 52                  | 264               | 52                   | 259               |
| 53                  | 241               | 53                   | 253               |
| 54                  | 241               | 54                   | 238               |
| 55                  | 236               | 55                   | 238               |
| 56                  | 234               | 56                   | 233               |
| 57                  | 230               | 57                   | 232               |
| 58                  | 228               | 58                   | 226               |
| 59                  | 225               | 59                   | 226               |
| 60                  | 224               | 60                   | 221               |
| 61                  | 218               | 61                   | 219               |
| 62                  | 214               | 62                   | 208               |
| 63                  | 207               | 63                   | 202               |
| 64                  | 201               | 64                   | 195               |
| 65                  | 200               | 65                   | 191               |
| 66                  | 186               | 66                   | 185               |
| 67                  | 176               | 67                   | 178               |
| 68                  | 163               | 68                   | 160               |
| 69                  | 156               | 69                   | 159               |
| 70                  | 154               | 70                   | 149               |
| 71                  | 137               | 71                   | 146               |
| 72                  | 131               | 72                   | 121               |
| 73                  | 77                | 73                   | 89                |
| 74                  | 70                | 74                   |                   |

Table V (b) Problem Section of Geometry Test. The reckoning of the total number of correct responses on newly constructed test from correct responses each test element received in the original testing.

| Form A              |                   | Form B              |                   |
|---------------------|-------------------|---------------------|-------------------|
| No. of test element | Correct responses | No. of test element | Correct responses |
| 1                   | 815               | 1                   | 790               |
| 2                   | 592               | 2                   | 711               |
| 3                   | 548               | 3                   | 569               |
| 4                   | 536               | 4                   | 530               |
| 5                   | 523               | 5                   | 495               |
| 6                   | 513               | 6                   | 492               |
| 7                   | 476               | 7                   | 443               |
| 8                   | 382               | 8                   | 419               |
| 9                   | 378               | 9                   | 353               |
| 10                  | 352               | 10                  | 315               |
| 11                  | 221               | 11                  | 269               |
| 12                  | 199               | 12                  | 200               |
| 13                  | 183               | 13                  | 188               |
| 14                  | 179               | 14                  | 170               |
| 15                  | 168               | 15                  | 168               |
| 16                  | 160               | 16                  | 156               |
| 17                  | 138               | 17                  | 137               |
| 18                  | 123               | 18                  | 109               |
| 19                  | 102               | 19                  | 94                |
| 20                  | 80                | 20                  | 81                |
| 21                  | 58                | 21                  | 52                |
| 22                  | 52                | 22                  | 47                |
| 23                  | 50                | 23                  | 41                |
| 24                  | 40                | 24                  | 39                |
| 25                  | 34                | 25                  | 35                |
| 26                  | 33                | 26                  | 34                |
| 27                  | 23                | 27                  | 26                |
| 28                  | 23                | 28                  | 23                |
| 29                  | 19                | 29                  | 22                |
| 30                  | 1                 |                     |                   |
| Total               | <u>7001</u>       | Total               | <u>7008</u>       |

Table V (c) Logical Selection Section of Geometry Test.  
 The reckoning of the total number of correct responses  
 on newly constructed test from correct responses each  
 test element received in the original testing.

| Form A                 |                      | Form B                 |                      |
|------------------------|----------------------|------------------------|----------------------|
| No. of test<br>element | Correct<br>responses | No. of test<br>element | Correct<br>responses |
| 1                      | 682                  | 1                      | 682                  |
| 2                      | 664                  | 2                      | 666                  |
| 3                      | 640                  | 3                      | 581                  |
| 4                      | 552                  | 4                      | 562                  |
| 5                      | 518                  | 5                      | 476                  |
| 6                      | 464                  | 6                      | 465                  |
| 7                      | 462                  | 7                      | 455                  |
| 8                      | 432                  | 8                      | 432                  |
| 9                      | 390                  | 9                      | 377                  |
| 10                     | 370                  | 10                     | 373                  |
| 11                     | 357                  | 11                     | 348                  |
| 12                     | 334                  | 12                     | 347                  |
| 13                     | 332                  | 13                     | 334                  |
| 14                     | 319                  | 14                     | 320                  |
| 15                     | 317                  | 15                     | 310                  |
| 16                     | 301                  | 16                     | 306                  |
| 17                     | 298                  | 17                     | 288                  |
| 18                     | 284                  | 18                     | 284                  |
| 19                     | 280                  | 19                     | 271                  |
| 20                     | 255                  | 20                     | 266                  |
| 21                     | 244                  | 21                     | 255                  |
| 22                     | 238                  | 22                     | 241                  |
| 23                     | 231                  | 23                     | 222                  |
| 24                     | 196                  | 24                     | 217                  |
| 25                     | 193                  | 25                     | 188                  |
| 26                     | 173                  | 26                     | 180                  |
| 27                     | 170                  | 27                     | 168                  |
| 28                     | 163                  | 28                     | 167                  |
| 29                     | 161                  | 29                     | 159                  |
| 30                     | 157                  | 30                     | 157                  |
| 31                     | 148                  | 31                     | 120                  |
| 32                     | 115                  | 32                     | 117                  |
| 33                     | 110                  | 33                     | 101                  |
| 34                     | 101                  | 34                     | 99                   |
| 35                     | 99                   | 35                     | 27                   |
| Total                  | <u>10750</u>         | Total                  | <u>10361</u>         |

Table VI Revised Geometry Test of True-False Section showing the number and Form of the test element and its original number and Form.

| Form A              |                       | Form B              |                       |
|---------------------|-----------------------|---------------------|-----------------------|
| No. of test element | Original Form and No. | No. of test element | Original Form and No. |
| 1                   | A-44                  | 1                   | A-37                  |
| 2                   | B-6                   | 2                   | B-3                   |
| 3                   | B-49                  | 3                   | B-27                  |
| 4                   | A-26                  | 4                   | A-16                  |
| 5                   | B-5                   | 5                   | B-2                   |
| 6                   | B-64                  | 6                   | B-12                  |
| 7                   | B-13                  | 7                   | B-40                  |
| 8                   | B-48                  | 8                   | B-7                   |
| 9                   | A-59                  | 9                   | B-46                  |
| 10                  | A-28                  | 10                  | A-46                  |
| 11                  | B-25                  | 11                  | A-53                  |
| 12                  | A-2                   | 12                  | A-55                  |
| 13                  | B-18                  | 13                  | A-5                   |
| 14                  | B-20                  | 14                  | B-35                  |
| 15                  | A-33                  | 15                  | A-47                  |
| 16                  | B-37                  | 16                  | B-31                  |
| 17                  | A-12                  | 17                  | A-25                  |
| 18                  | A-40                  | 18                  | B-51                  |
| 19                  | B-52                  | 19                  | A-63                  |
| 20                  | A-35                  | 20                  | A-32                  |
| 21                  | B-38                  | 21                  | B-71                  |
| 22                  | A-31                  | 22                  | B-30                  |
| 23                  | B-11                  | 23                  | B-28                  |
| 24                  | A-43                  | 24                  | B-42                  |
| 25                  | A-50                  | 25                  | B-54                  |
| 26                  | A-19                  | 26                  | A-64                  |
| 27                  | B-16                  | 27                  | A-71                  |
| 28                  | B-56                  | 28                  | B-69                  |
| 29                  | A-21                  | 29                  | A-9                   |
| 30                  | A-17                  | 30                  | A-10                  |
| 31                  | B-24                  | 31                  | A-20                  |
| 32                  | A-68                  | 32                  | A-24                  |
| 33                  | A-32                  | 33                  | A-69                  |
| 34                  | B-17                  | 34                  | A-36                  |
| 35                  | A-3                   | 35                  | A-13                  |
| 36                  | A-67                  | 36                  | A-54                  |
| 37                  | B-58                  | 37                  | B-34                  |
| 38                  | B-23                  | 38                  | A-14                  |
| 39                  | A-56                  | 39                  | A-27                  |
| 40                  | A-57                  | 40                  | A-22                  |

| Form A              |                       | Form B              |                       |
|---------------------|-----------------------|---------------------|-----------------------|
| No. of test element | Original Form and No. | No. of test element | Original Form and No. |
| 41                  | A-66                  | 41                  | B-29                  |
| 42                  | A-23                  | 42                  | B-50                  |
| 43                  | A-36                  | 43                  | B-73                  |
| 44                  | A-4                   | 44                  | B-70                  |
| 45                  | A-72                  | 45                  | A-83                  |
| 46                  | A-60                  | 46                  | A-41                  |
| 47                  | A-70                  | 47                  | A-82                  |
| 48                  | B-42                  | 48                  | B-55                  |
| 49                  | B-88                  | 49                  | B-83                  |
| 50                  | B-60                  | 50                  | A-73                  |
| 51                  | A-75                  | 51                  | A-34                  |
| 52                  | B-67                  | 52                  | A-76                  |
| 53                  | B-79                  | 53                  | B-81                  |
| 54                  | B-41                  | 54                  | A-90                  |
| 55                  | B-84                  | 55                  | B-68                  |
| 56                  | A-61                  | 56                  | A-81                  |
| 57                  | B-33                  | 57                  | A-86                  |
| 58                  | A-77                  | 58                  | B-74                  |
| 59                  | B-78                  | 59                  | B-76                  |
| 60                  | A-39                  | 60                  | A-45                  |
| 61                  | B-45                  | 61                  | A-62                  |
| 62                  | A-53                  | 62                  | B-9                   |
| 63                  | A-11                  | 63                  | A-85                  |
| 64                  | B-66                  | 64                  | B-75                  |
| 65                  | B-80                  | 65                  | B-59                  |
| 66                  | B-82                  | 66                  | A-84                  |
| 67                  | A-30                  | 67                  | B-62                  |
| 68                  | A-65                  | 68                  | B-57                  |
| 69                  | A-49                  | 69                  | B-61                  |
| 70                  | A-48                  | 70                  | B-8                   |
| 71                  | A-88                  | 71                  | A-74                  |
| 72                  | A-79                  | 72                  | B-89                  |
| 73                  | A-87                  | 73                  | B-87                  |
| 74                  | B-77                  | 74                  |                       |

Table VI (b) Revised Geometry test of Problems Section showing the number and Form of the test element and its original number and form.

| Form A              |                       | Form B              |                       |
|---------------------|-----------------------|---------------------|-----------------------|
| No. of test element | Original Form and No. | No. of test element | Original Form and No. |
| 1                   | B-1                   | 1                   | A-1                   |
| 2                   | A-21                  | 2                   | B A-2                 |
| 3                   | A-10                  | 3                   | A-9                   |
| 4                   | A-5                   | 4                   | B-32                  |
| 5                   | A-22                  | 5                   | A-24                  |
| 6                   | A-3                   | 6                   | B-8                   |
| 7                   | A-39                  | 7                   | A-28                  |
| 8                   | A-19                  | 8                   | A-23                  |
| 9                   | A-14                  | 9                   | B-30                  |
| 10                  | B-28                  | 10                  | B-31                  |
| 11                  | A-30                  | 11                  | B-3                   |
| 12                  | A-18                  | 12                  | B-7                   |
| 13                  | A-7                   | 13                  | B-16                  |
| 14                  | A-4                   | 14                  | A-20                  |
| 15                  | B-6                   | 15                  | B-12                  |
| 16                  | A-15                  | 16                  | A-6                   |
| 17                  | A-40                  | 17                  | B-23                  |
| 18                  | A-36                  | 18                  | B-14                  |
| 19                  | A-11                  | 19                  | B-40                  |
| 20                  | B-15                  | 20                  | B-33                  |
| 21                  | B-36                  | 21                  | B-17                  |
| 22                  | B-9                   | 22                  | A-33                  |
| 23                  | A-35                  | 23                  | A-25                  |
| 24                  | A-16                  | 24                  | B-13                  |
| 25                  | A-42                  | 25                  | B-39                  |
| 26                  | A-32                  | 26                  | B-43                  |
| 27                  | A-13                  | 27                  | A-39                  |
| 28                  | B-27                  | 28                  | B-42                  |
| 29                  | A-31                  | 29                  | B-11                  |
| 30                  | "-43                  |                     |                       |

Table VI (c) Revised Geometry Test of Logical Selection showing the number and Form of the test element and its Original number and form.

| Form A              |                       | Form B              |                       |
|---------------------|-----------------------|---------------------|-----------------------|
| No. of test element | Original Form and No. | No. of test element | Original Form and No. |
| 1                   | A-1                   | 1                   | B-18                  |
| 2                   | A-2                   | 2                   | B-20                  |
| 3                   | B-2                   | 3                   | A-30                  |
| 4                   | A-14                  | 4                   | A-5                   |
| 5                   | B-14                  | 5                   | A-11                  |
| 6                   | A-31                  | 6                   | A-33                  |
| 7                   | A-29                  | 7                   | A-15                  |
| 8                   | A-7                   | 8                   | B-7                   |
| 9                   | B-4                   | 9                   | B-25                  |
| 10                  | A-10                  | 10                  | B-16                  |
| 11                  | A-20                  | 11                  | B-12                  |
| 12                  | B-10                  | 12                  | B-27                  |
| 13                  | A-34                  | 13                  | B-40                  |
| 14                  | B-33                  | 14                  | A-35                  |
| 15                  | B-3                   | 15                  | B-15                  |
| 16                  | B-30                  | 16                  | B-31                  |
| 17                  | A-5                   | 17                  | A-22                  |
| 18                  | B-23                  | 18                  | A-18                  |
| 19                  | B-38                  | 19                  | B-39                  |
| 20                  | A-19                  | 20                  | B-26                  |
| 21                  | A-17                  | 21                  | B-11                  |
| 22                  | A-16                  | 22                  | B-9                   |
| 23                  | A-28                  | 23                  | A-36                  |
| 24                  | A-9                   | 24                  | A-38                  |
| 25                  | B-8                   | 25                  | B-34                  |
| 26                  | A-40                  | 26                  | B-32                  |
| 27                  | B-17                  | 27                  | B-41                  |
| 28                  | A-21                  | 28                  | A-24                  |
| 29                  | B-21                  | 29                  | A-8                   |
| 30                  | B-19                  | 30                  | A-27                  |
| 31                  | A-37                  | 31                  | B-28                  |
| 32                  | A-41                  | 32                  | A-26                  |
| 33                  | B-13                  | 33                  | B-24                  |
| 34                  | B-22                  | 34                  | A-6                   |
| 35                  | B-39                  | 35                  | A-39                  |