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An Experimental Evaluation of Television Instruction in the Field of College Physical Science

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Loyola University Chicago

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AN EXPERIMENTAL EVALUATION OF TELEVISION INSTRUCTION
IN THE FIELD OF COLLEGE PHYSICAL SCIENCE

by

F. Russell Koppa

A Dissertation Submitted to the Faculty of the Graduate School
of Loyola University in Partial Fulfillment of
the Requirements for the Degree of
Doctor of Philosophy

June
1960
LIFE

F. Russell Koppa was born in Chicago, Illinois on July 21, 1917. He is married and has three children.

He was educated in the Chicago public schools graduating from Carl Schurz High School in July, 1934 and from the Wright Branch of the Chicago City Junior College in June, 1936. Loyola University of Chicago conferred on him the degree of Bachelor of Science in Chemistry in June, 1938 and the degree of Master of Science in Chemistry in February, 1940. He pursued graduate work in chemistry at Loyola University of Chicago through August, 1940; thereafter he engaged in graduate work and research in Chemistry at Northwestern University, Evanston, Illinois from September, 1940 through June, 1943.

The author served as a teaching assistant in Chemistry at Loyola University from July, 1938 through June, 1940, and he also served in the same capacity at Northwestern University from September, 1941 through August, 1943. Throughout the summer of 1940 the author was analytical paint chemist at Sherwin-Williams Co., Chicago. He was Director of the Chemical Laboratories of the Belmont Radio Corporation of Chicago from September, 1943 through December, 1945. During the summer of 1956 Great Lakes Carbon Co. of Morton Grove, Illinois employed him as Research Chemist.

From September, 1943 until the college closed in 1950 the author taught
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In January, 1946 the author became a member of the Physical Science Department of the Wright Branch of the Chicago City Junior College. He still serves in this capacity. The author possesses teachers' certificates in high school chemistry and college chemistry and a principal's certificate from the Chicago Board of Education.

The author's publications follow:

**Articles**

"Constant Humidity Chambers," The Milvay Notebook, Winter, 1944-45


**Textbooks and workbooks**


*Exercises in Physical Science 102.* Ann Arbor, 1957. Authors: Koppa (editor) et al.


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The author's wife, Della Gadecki Koppa, conceived the idea of initiating doctorate work in education. She consequently assumed many more duties and responsibilities to make this work possible. Her encouragement, help, understanding, and—when necessary—prodding are appreciatively acknowledged.

Dr. Max D. Engelhart has been a constant source of inspiration and encouragement. At any hour of the day or night he has given freely of his time. His contributions have been well beyond those normally expected of a research director. Words are inadequate in expressing the author's appreciatiiveness to and admiration for this gentleman and scholar.
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CHAPTER I

THE PROBLEM

Technical developments in the late 1940's and early 1950's made television a reality; it became a medium of "mass" communication. It is not surprising therefore that television was quickly utilized as an instructional tool. Progress in educational television was, at first, extremely slow due perhaps to costs in establishing and operating standard stations. Steady gains have been made.

The state University of Iowa's experimental station W9XX between 1932 and 1939 was probably one of the most extensive early endeavors in educational television programming. Iowa State College's WOI-TV, licensed by 1948, was the first TV station owned by an educational institution.

In 1952 the Federal Communications Commission allocated 242 channels to noncommercial use. Kansas State College in Manhattan, Kansas became the first educational institution to be granted a construction permit on July 24, 1952. About this time many foundations contributed funds for the development of educational television. Five million dollars was granted by The Fund for Adult Education to assist in educational TV station construction and program development.1

1William Kenneth Comming, This is Educational Television (Ann Arbor, 1954), p. 5.
Much of the original television programming was presented by commercial stations. Educational television offerings may now be grouped into several categories: 1) those in which most of the programming is presented on commercial networks, 2) those in which the efforts are closely coordinated with those of a commercial station, 3) those which are programmed on commercial outlets, and 4) those which are presented by non-commercial educational television stations.

Most of the programming of Johns Hopkins University, the University of Pennsylvania, and Columbia University are presented on commercial networks. Johns Hopkins is regarded as the pioneer in educational institution TV production.

The Johns Hopkins Science Review began on a local basis in March, 1948. In December, 1948 the show was requested by the Columbia Broadcasting System for its network. The Science Review is strictly an "informational" program with topics selected on the basis of their probable interest to laymen.

In the spring of 1952 the University of Pennsylvania dramatized the role of higher education in community and national life in the American Tradition. What in the World, begun in 1951, was a panel program in which archeological experts tried to identify museum items.

Columbia University's Horizons went on the air via the ABC network in December of 1951. These programs explored the subject of the future of women and such fields as psychiatry, theatre and poetry, race relations, and the future of the family. These shows were produced to tell the public

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2 Ibid., p. 11.
of the activities of a large university. Another program, Seminar, explored the development of U.S. institutions and social ideas.

The first institution in the country to use professional television production equipment on its campus was Creighton University in Omaha. In July, 1947 they presented a one-act play. In July, 1948 TV viewers were able to watch an orchestra, a biology program, and a demonstration of dental surgery. In November, 1949 with Creighton University Presents each department of the University over an eight week period demonstrated its work over WOW-TV. In January, 1953 Creighton alternated its offerings throughout the week with the University of Nebraska and the University of Omaha. Syracuse University utilizes its television training program for graduate students only. The university opened the country's first university owned and operated TV studio in April, 1950. WSYR-TV is charged on a camera-hour basis for its shows. The University of Miami has been particularly successful with programs relating to life in southeastern Florida and presented in laymen terms. The emphasis at Miami is "not on programs for their own sake, but on training." 4

Many schools program their offerings on commercial outlets. The University of Buffalo Round Table has been a regular weekly offering since May, 1948; this features a panel of four discussing problems of local, national, or international significance. Their Modern Medicine, begun in

3 Ibid., p. 17.
4 Ibid., p. 25.
March, 1953, depicts recent advances in medicine and surgery. The Law and You presents legal problems confronting the average citizen. In October, 1949 The State Teachers College in Millersville, Pennsylvania initiated its What Do You Want To Know program over WUAL-TV. Both the college and the station regard Millersville's TV programs as a public service.

Most of the programs of the State University of Iowa have been recorded on the campus since the fall of 1953. Their TV programming, however, was begun in November, 1949. Since the 1953-54 school year the major portion of the school's TV productions have been kinescoped. The State University of Iowa operated the largest educational institution-owned TV laboratory in the country.

The Atlanta Division of the University of Georgia has been operating on WAGA-TV since April, 1949. Examples of their programs include 15-minute language programs in French, Spanish, or German which give no college credit. Successful completion of an oral examination taken at the university entitles the candidate to a certificate of completion.

Station WFIP-TV in Philadelphia cooperates with educational institutions in its area for its public service programming. Nineteen of the twenty-four colleges and universities in the area accepted the station plan for November, 1950. The first services on The University of the Air began in January, 1951. Program offerings range over many fields: international relations, physics, chemistry, psychology, folk music and literature, economics, architecture, history, the scientific method, public speaking, ornithology, today's newspapers, art, commerce, and many others. Viewers
who want outlines and reading lists of TV courses may obtain them for 25 cents."

By early 1956 twelve educational television stations carried "programs designed for children to watch while in school and twelve stations were carrying formal higher educational courses. By late 1955 at least fifty-six colleges and universities offered more than two hundred courses for academic credit via commercial and educational television stations." 6

Kumata states that in 1956 there were "at least 47 in-school viewing efforts by as many school systems, 406 credit and non-credit courses put on by 77 different colleges and universities, and at least 29 closed-circuit teaching programs." 7

By the beginning of 1958 there were more

than 100 institutions of higher education...broadcasting non-credit courses over commercial stations...and about 50 public, private, and parochial schools; county and state boards of education; and community educational television councils or groups are telecasting educational programs. Courses for credit have been telecast by more than 40 institutions of higher education over commercial stations. Today about two dozen such institutions are conducting credit courses over non-commercial television stations. Educational stations alone this year are conducting almost 200 regular courses for high school or college credit.

At the elementary and secondary levels we find open circuit telecasting in almost every type of course: arithmetic, English, reading, nature study, general science, physics, history, health, algebra,

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5 Ibid., p. 33.


geometry, art, trigonometry, chemistry, spelling, music, modern languages, and driver education. Alabama, Nebraska, North Carolina, and Oklahoma are operating on a state-wide basis, while important projects are underway in Atlanta, Boston, Cincinnati, Detroit, Milwaukee, Norfolk, Philadelphia, Pittsburgh, and St. Louis.

Closed circuit operations on a limited basis are taking place in dozens of cities. The most comprehensive closed circuit operation is in Washington County, Maryland.

At the college level, credit courses are being offered through closed circuit systems at Penn State University, Case Institute of Technology, the University of Minnesota, Washington State College, New York University, and Miami (Ohio) University.

Open circuit work at the college level is taking place on a limited basis at over two dozen institutions, with probably the most extensive projects being carried on at the University of Detroit, where the full freshman year is being offered, at San Francisco State College, where four courses are being given, and at Chicago, where a full two-year freshman and sophomore curriculum is being offered.

The 1959 Educational Television Directory lists 248 educational television channel reservations with 35 educational stations on the air in 24 states and Puerto Rico. Closed circuit television is being used for educational purposes in at least 37 states. Alabama's statewide network offers programs "ranging from direct teaching on all academic levels to those addressing a large general audience. A combined total of more than 250 schools are utilizing the network's televised lessons, either for direct teaching or enrichment." San Francisco offers direct teaching lessons on the elementary, secondary, and college level as well as informal programs for

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adults. Junior colleges, colleges, and medical colleges, as in California, use closed circuit TV instruction extensively. Direct televised instruction and enrichment programs in subjects like music and history are presented to students in many Delaware public schools. Hagerstown, Maryland and St. Louis, Missouri offer an entire range of public school curricula subjects for grades one through twelve.

Some high school systems, like those in Macon, Georgia and Oxford, Mississippi, offer a complete physics course telecast by commercial stations. Five subjects are taught to more than 700 students in Evanston Township High School via closed circuit TV. In Lincoln, Nebraska 490 students in 29 high schools within a 60-mile range are enrolled in TV correspondence courses in mathematics, the physical sciences, art, American literature, and Spanish.

Many adult education courses are offered throughout the country at the high school and college level.

Closed circuit instruction is offered via 133 closed circuit systems in 119 educational institutions.\(^{10}\) The instruction ranges from first grade through postgraduate college. In addition 21 military installations use closed circuit television for instruction and training purposes.

In May, 1956 the Chicago Public School started experimentation with television instruction by televised advanced algebra to 545 students and high school physics to 630 students in thirty-four Chicago public high

schools. Ten consecutive lessons in each of these subjects, originating from Chicago's educational television station, WTTW, were viewed by students in their classrooms. First year high school English composition was offered via television involving half-hour telecasts each Sunday morning as a general service feature of NBC. The students attended one regular class meeting each week at one of seven public evening high schools.\footnote{11}

In the February to June semester of 1957 the filmed high school physics course of Dr. Harvey White of the University of California and of the National Science Foundation was telecast to 700 bright 15, 16, and 17 year old students in 25 Chicago Public High Schools. The second semester of the high school physics course was offered to 311 students in 10 high schools via television throughout the summer of 1957.\footnote{12}

In the fall of 1956 the Chicago City Junior College began its three year program of experimentation with television instruction. The experiment was made possible by the Chicago Board of Education and, through its generous grants, by the Fund for the Advancement of Education. The program has been organized and coordinated under the direction and guidance of Clifford Erickson, Assistant Dean in Charge of Television. Open circuit televising

\footnote{11}Max D. Engelhart, \textit{Teaching by Television in the Chicago Public Schools}, a paper presented at the annual meeting of the American Educational Research Association at Atlantic City, February 16-20, 1957.

\footnote{12}Max D. Engelhart, Edward G. Schwachtgen, and Mary M. Nee, \textit{The Chicago Public Schools Television Instruction Experiment in High School Physics}, a mimeographed report.

Engelhart, Schwachtgen, and Nee.
was presented by Channel 11, WTTW. Max D. Engelhart, Director of Student Examinations of the Chicago City Junior College, and Hyman Chausow, Director of Research of the Television Office, helped in planning the design of the experiment, in developing the evaluative instruments used, and in analyzing and interpreting the results. 13

In the fall of 1956 elementary courses in college English, biology, social science, and political science were offered. In the first semester about seventy teachers were involved in the course offerings. In the Spring of 1957 the first course in English was repeated and the second semester of the required year's sequence in English, biology, and social science was televised. In addition a first course in college mathematics was given.

In the Fall of 1957 TV College repeated the elementary courses in English and biology using kinescopes of the original presentations. Elementary courses in the physical sciences, the humanities, beginning accounting, Gregg shorthand, and psychology were offered.

Evaluation of instructional television programming has greatly lagged behind actual performance. The results of research are small when compared to "at least 47 in-school viewing efforts by as many different colleges and universities, and at least 29 closed-circuit teaching programs." 14

It can be assumed that not all instructional television programs need


14 Kumata, p. 1.
be burdened with an experimental research program. When an evaluation of an instructional television program is to be made, most authorities believe that the evaluation program should be considered at the planning stage, should be in terms of the objectives to be accomplished, and should be considered in preparing the necessary conditions for testing the hypotheses raised.

There are several reasons why instructional television evaluation lags behind performance. First, the costs of producing and transmitting a television course may be so great as to preclude research expenditures. Second, criteria upon which to measure effectiveness of instruction do not seem to be clear to all sponsors. In some cases large credit enrollment is stressed; in other cases stress is placed upon the casual observer. Third, the control of extraneous variables for research purposes is difficult. This is of particular importance in open broadcasts where viewers cannot be reached by research personnel. Closed-circuit television affords an excellent way of controlling the "captive audience."

As a whole the quality of studies which have been made is disappointing and can be improved. Some of the reasons for this have already been cited. Much of the lack of quality is due to the absence of careful planning for the evaluation. Some of the best and most systematic studies are those which have been sponsored by the Armed Forces and those supported by foundation grants. Most of such studies have been closed-circuit.

The tenor of many reports can be summarized by Huston Smith's report of

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his impressions concerning a six week course given by him on "The Religions of Man" during the spring of 1955 in St. Louis:

I do not pretend to have demonstrable answers to ... questions. Every educator realizes how difficult it is to gauge authentic response even when the student is at close range. Who knows who learns?

Without any "before and after" interview data, without even having seen the bulk of my viewers, all I come out with is an impression. But it is a strong one. 16

The present study is concerned with the Chicago City Junior College offering in the physical sciences, Physical Science 101. It is believed that this is the first television offering of an integrated college physical science course; thus, no previously collected evaluation data specific to this field are available. A few evaluations of high school and college courses in physics, chemistry, and engineering, however, have been reported. 17

In other areas extensive literature on television instruction is available.


17 For example: Conrad V. Hatch, Student Attitudes Toward TV as a Medium of Instruction: Report for CC 507, College Teaching Studies (Oregon State College, May 1957)


W. F. Seibert, A Brief Report and Evaluation of Closed-Circuit Television Instruction in Mechanical Engineering 360 (Purdue University, Audio-Visual Center. A mimeographed report.)

John R. Martin, Two-Way Closed-Circuit Educational Television. Research Reports No. 2h8-1, 2h8-2, and 2h8-2. (Case Institute of Technology, Cleveland, Ohio, January 1957, February 1957, and July 1957 respectively.
Physical Science 101 is the first course of the two semester sequence in the physical sciences required for graduation by the Chicago City Junior Colleges. The television course consisted of forty-five telecasts of thirty minute duration as follows: two telecasts on an introduction to science and methods of science; ten telecasts and demonstrations on descriptive geology involving the study of rocks and the rock cycle, weathering and erosion, the gradational effects of ground water, running water, and ice, and diastrophism and volcanism, three telecasts of historical geology, and one telecast of the geology of the Chicago area; five telecasts on meteorology and weather forecasting; fourteen telecasts dealing with astronomy including the motions of the earth and the other heavenly bodies, time and the seasons, theories of the solar system, the sun, moon, and planets, and the origin of the solar system; nine telecasts devoted to the metric system, motion, work, energy, and heat and its applications; and a final summary telecast.

The course was organized and presented by Irving Slutsky, at that time a member of the Physical Science Department of the Wright Branch of the Chicago City Junior College. Joseph Jerome, of the Wilson Branch of the Chicago City Junior College, was the second member of the team preparing the course. Mr. Slutsky had had about ten years experience in offering the Physical Science 101 course. Live telecasts were made three times a week (except for school holidays) at 3:00—3:30 p.m. Kinescopes of these discussions were presented at 7:30—8:00 p.m. one week later.

The course organization is that regularly used by the Wright physical science faculty and is essentially the same as that employed at the various
branches of the Chicago City Junior College. The time schedule and topic sequence of the televised course was that used by the Wright Branch; this schedule and sequence was adopted by all branches of the Chicago City Junior College during the semester of the TV offering. The textbook was that which had been used for many years by the faculties of the Chicago City Junior College.18

The TV students were required to mail a weekly homework assignment to the TV college office at the Wright Branch where the papers were graded by a group of students working under the direction of Mr. Slutsky. The graded papers, along with a mimeographed key, were mailed to the students in their self-addressed, stamped envelopes. The homework exercises were adaptations from a workbook prepared by the physical science faculty of the Wright Branch and used at the Wright Branch for students regularly enrolled in Physical Science 101. At the Wright Branch keys to the homework exercises were posted on a departmental bulletin board for use by regularly enrolled students.

Throughout the semester all students (both TV and those regularly enrolled) took two hourly examinations, one at the end of the geology section and the other at the end of the meteorology and astronomy section. The final examination was of two hours duration. All students took the examinations at the branch of the Chicago City Junior College at which they had enrolled with the exception of the "handicapped students." Handicapped students are those who are unable to report to the college because of physical handicaps or in-

carceration at a prison or reformatory. These students took the examination under the supervision of individuals approved by the TV college dean.

Uniform methods of marking were applied to all students. The two hourly examinations constituted fifty percent of the final mark; the final examination accounted for the other fifty percent.

At the outset it was decided that a detailed study of the physical science achievement should be made. The TV College dean, Clifford Erickson, granted permission to make all records available to the author. Throughout the experiment the various faculties of the branches of the Chicago City Junior College were extremely cooperative. All test data were tabulated and organized at the Department of Examinations of the Chicago City Junior College.

There have been many opponents to offering television courses for college credit. Some of this opposition may be sheer inertia. The feeling may be that since instruction by television is new and untried one should proceed cautiously until definite proof is attained of the fact that television students achieve equally as well as students instructed by conventional classroom methods. According to the advocates of this view one must maintain the quality of college instruction; if even the faintest suggestion of the lack of maintenance of college standards exists, college credit should be denied. In this way the purity (and it is hoped quality) of college instruction can be maintained.

The present study, accordingly, will attempt to answer the question with regard to the quality of attainment of students instructed via television as compared to those instructed in conventional classrooms. The viewpoint which
will be assumed is that if college credit is to be given on the basis of the quality of performance of a student based on his achievement on instructors' or standardized objective tests, then there should be no qualms about assigning college credit to students who achieve equally well—regardless of the kind of instruction received—on objective tests and who complete all course requirements. If, however, students instructed via television generally attain much more poorly on objective tests than do regularly instructed students, then one should, depending on the extent of differences in attainment, question whether it is proper to offer college credit to the television instructed student. The answer to this question is, of course, not at all related to the question as to whether TV instruction is relatively better or worse than regular instruction.

The present study will not concern itself with those opponents of instruction via television who feel that television instruction poses a threat to the teaching profession. Here, they feel, is an attempt on the part of administration for one reason or another to replace the classroom instructor. Since this poses a threat to teachers and gives them a feeling of insecurity, opponents maintain that at all costs television instruction must be vigorously opposed.

This controlled educational experimentation is aimed at an evaluation of the relative effectiveness of televised physical science instruction compared to usual classroom instruction. The research is concerned with the collection, organization, and interpretation of the experimental data for the purpose of studying the relative effectiveness of televised versus regular instruction in college physical science.
The study is an attempt to evaluate student attainment of such objectives as

1) knowledge and understanding of content (i.e., informational background, terms, and concepts),

2) critical thinking (i.e., applications of knowledge) in the field of the physical sciences, and

3) interests and attitudes toward the course and toward science.

The results also aim to

1) compare the relative achievement of day, evening, and TV registrants,

2) compare experienced and novice instructors at one of the branches of the Chicago City Junior College, and

3) compare conventional instruction versus TV instruction for various ability groups based on initial intelligence and proficiency in an initial pretest.

This chapter has been concerned with a summary of the development of educational television and with the statement and definition of the problem of this dissertation. Chapter II presents a summary of the previous research relevant to the problem. In Chapter III are reported the experimental data collected for this study. Chapter IV presents the treatment of the data by analysis of covariance and Chapter V their treatment by methods by levels analysis of variance. Chapter VI also includes data on item analysis. In Chapter VII are given the conclusions derived from this experimentation.
CHAPTER II

SUMMARY OF PREVIOUS RESEARCH

Much of the instructional research in the field of educational television has been limited to closed-circuit production. Frequently the research originated in an attempt to answer inquiries from administrators concerning the learning of subject matter content. As a result many of the studies have been concerned with the premise that course content could be taught as effectively via television as in the conventional classroom. In general no conclusive results have been provided.

This chapter will be primarily concerned with the general effectiveness of television instruction vs. classroom instruction as well as the question of different ability levels of students achieving more by television instruction than by regular classroom instruction.

Where a number enclosed in parentheses appears—as for example (6)—this would indicate that the findings were indicated in the sixth reference in the bibliography at the end of the dissertation.

One of the most comprehensive and authoritative compilations of early research in instructional television is the Kumata Inventory which abstracts and interprets the findings prior to its publication in 1956. Many of the individual original sources, because of their informal publication, are
Unfortunately now unavailable. Great reliance has been placed on this

Inventory.

Kumata's Inventory categorizes the findings in terms of sixteen questions. Those of interest in the present study are:

1. How do students taught by TV compare with those taught by other media?
2. Who learns best by television?
3. What are attitudes toward learning by television?
4. What are the most liked features of telecourses?

In biology and psychology Evans, Roney and McAdams (24) found no significant differences on final examination performance between TV students and on-campus students. No significant differences in achievement between TV and classroom instructed students in chemistry, psychology, child psychology, and home nursing were found in several studies (3, 45, 52). On tests over sections covered by TV three Purdue TV classes did as well as non-TV students in analytic geometry, chemistry and bacteriology (10). No differences were found between TV and regular classroom students in high school mathematics and physics (58). In a psychology of adjustment course students taking the course via TV did better than two on-campus classes taught conventionally (32).

Many studies are concerned with armed services personnel. In radio electronic courses by TV about one-half of army personnel did as well as regularly instructed students on an achievement test (27). No significant differences in test scores of 12 of 17 tests were found between TV instructed and regularly instructed basic trainees (36). The TV group attained higher
scores in 5 of the 17 tests. TV students in the Naval Academy scored significantly higher than regular classroom students in two electronic courses while the regular classroom students did significantly better in another course (6). TV students did slightly poorer in a food service course for ROTC students than did those taught by regular classroom procedures (2).

The major findings of his 1956 Inventory were summarized by Kumata.  

1. On subject matter tests, television students did just as well as conventionally taught students and at times did somewhat better.

2. On short term retention tests on subject matter content, television students did just as well as conventionally taught students.

3. Acceptance of television by students varied.

4. Increasing the size of classes, having proctors in the television room, providing for talk-back facilities did not have any significant effect on amount learned for television students.

5. It was uncertain whether a novelty effect existed or not.

6. Very little work had been done on change of attitudes toward subject matter content through presentation by television.

In his Attitude Change ... two years later Kumata reports that contrary to the majority of television studies TV students at Michigan State University did more poorly in a Social Science project and an Advertising project than conventionally taught students.

More recent research to some degree supplements and reinforces the earlier Inventory conclusions. A minority of results appear, however, which indicate that TV students achieved less well than conventionally taught students.

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1Hideya Kumata, Attitude Change and Learning as a Function of Prestige of Instructor and Mode of Presentation (Ann Arbor, 1958), pp. 2-3.
A majority of reports indicate that television instructed students and conventionally taught students seem to achieve equally as well with little or no significant differences. A preliminary study of chemistry via TV at Oregon State College found no significant differences in achievement between TV and regular students (30). In a study at Purdue using TV as one of a number of audio-visual aids in a General Chemistry Laboratory course, no significant differences were found between conventional methods, TV presentation, and optional TV viewing combined with shorter lab periods (31).

A Purdue calculus experiment resulted in very nearly equal achievement for conventionally and TV-taught students (13). San Francisco College (12), Pennsylvania State University in seven different courses (28), Rensselaer Polytechnic Institute in 12 Materials Lab experiments (57), New York University in "The History of Civilization" study (37), the University of Iowa in courses in communication skills and American government (4, 5), and Michigan State University in chemistry, communication skills, educational psychology, and social science (38) report little or no significant differences in achievement between regularly instructed and TV-instructed students.

In the study at the Chicago City Junior College though comparisons favored TV in courses in mathematics, English, and social science no significant differences were indicated (20). The seeming superiority of TV registrants was attributed to significant differences in age, maturity, and motivation.

In the Michigan State University's one lecture study in social science the immediate memory of material of the non-TV group was significantly better (38).
Highest achievement for the lecture group in the University of Iowa's modern literature course was indicated (5). In Speech I at the University of South Dakota (53), in English composition at Purdue University (50) and the 8-week physics study (48), and in foundations of human behavior, economics, and one of the two parts of the final examination in air science at Miami University of Ohio (43) TV students did not achieve as well as regular classroom and control students.

Macomber summarized his study of final examination data from four courses in the Spring semester of 1956 and four courses taught in both semesters of 1956-57 (1, pp. 21-22):

Results on eight out of the twelve semester examinations showed no significant differences in achievement. In four of the twelve cases, however, we found significant differences. The differences in three of these cases favored the control sections over the televised sections and in one instance the difference favored the televised section over the control section.

At New York University throughout a period of two semesters conventional students did better in college composition the first semester, but in the second semester the TV students fared better. No differences were significant (37).

In a followup study at Purdue University six of seven comparisons tended to favor the TV group, but only one of the differences was statistically significant (51). Statistical differences favoring TV were indicated at the Chicago City Junior College in courses in biology and social science (20).

A Chicago Public School ten day TV experiment in high school physics and algebra indicates a slight, but not statistically significant, advantage to groups taught partially on TV (42). In another high school physics ex-
periment bright students were taught physics using telecasts of Dr. Harvey White's filmed course. TV instructed students earned a higher average score though in one pair of groups of the same average and range of IQ's the final test score was the same for both groups. The results seem to indicate however that superior students of 120-125 IQ and above and students of below 100 IQ achieve relatively more from usual instruction than from TV instruction (19).

Fritschel compared the achievement of a general psychology class taught five weeks by closed-circuit TV with their previous achievement in six weeks of classroom presentation. He concluded that the average student remained at about the same achievement level but the variability increased. He noted that "the high achievement student became higher, and the low achievement student became somewhat lower" (26).

From the data available one may conclude that in general television students seem to achieve as well as conventionally taught students. At times the TV students seem to achieve somewhat better, but at times he also seems to achieve less.

In most of the studies of attitudes toward television the persons are asked to make comparisons with other courses they have had. The results should be interpreted with extreme caution.

In a study by Allen (2) a majority of television instructed students thought that the television material was about as easy to learn as that in the regular classroom. Most thought the TV lessons about the same or more interesting than other similar training periods. A majority of students feel that they learn as much by television instruction or a little less (8).
The TV and non-TV groups showed similar achievement test scores. Those who received classroom instruction rated psychology significantly higher in terms of contribution to their own educational advancement and of liking psychology.

Reservists instructed by TV thought the series interesting or very interesting (46). Signal corps students, pilot trainees, and psychology enrollees were favorable to TV instruction and seemed to prefer it (27, 25, 23).

It is interesting to note that in one study the student seemed to show a preference for the mode of instruction to which he had been exposed (45).

Though high school students achieved equally as well when instructed by television as by regular classroom instruction, high school teachers believed that TV was less effective than regular classroom instruction (58). The Kumata study indicated that "those who received the lecture in the face-to-face situation rated TV teaching as more interesting in comparison with TV students." In the same study it is interesting to note that students who had received TV instruction previously are more favorable towards teaching by television than first exposure students.

Summarizing recent and current studies limitations are noted:

1. Many of the studies are preliminary in nature.
2. Sometimes the studies are not sufficiently well planned.
3. The studies are frequently general in nature rather than specific.

One can therefore see that many questions of interest to those in the field of television instruction remain to be answered.

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2Kumata, Attitude Change and Learning, p. 100.
CHAPTER III

THE EXPERIMENTAL DATA

This study was conducted using the data of the Physical Science 101 offering of TV College in the Fall semester of 1957-58. Because of very small enrollments in the Crane Branch and particularly in the Amundsen Branch and Southeast Branch of the Chicago City Junior College it was decided to utilize only the data from the Wilson Branch and the Wright Branch in the statistical analyses.

At the time of initial registration all prospective TV students are required to take the thirty minute Otis Quick-Scoring Mental Ability Test: Gamma Test, Form EM. The test results yield information with regard to the initial mental ability of the students. For those students registering for the first time in the Fall of 1957-58 current data were available. The test results of those registering prior to the Fall of 1957-58 were obtained from the central files of the Department of Examinations.

At the time of registration for the Physical Science 101 television offering the student also took a thirty minute Physical Science pretest. The first six items of this test (see appendix) inquired of the students' background in science and mathematics, his age, the number of courses in which he was enrolled, and the number of hours worked per week. These items
were tabulated. The information attained is summarized on pages 76 and 78. The last fifty items of the test were objective test items covering the subject matter of the course. These items were chosen from old tests in the subject; item analyses concerning these items are available in the Department of Examinations of the Chicago City Junior College.

At the initial meeting(s) of the regular day and evening classes in Physical Science 101 the instructor administered the Otis test and the pre-test to the class. In a few cases students were absent from the initial class. Converted Otis scores were obtained for these students by obtaining from the Department of Examinations their scores on the Cooperative School and College Ability Test, Form IA. The conversions of the CAT test score to the Otis score was made using the results of some work done at the Department of Examinations. All tests were scored at the Department of Examinations. All answer sheets are retained by the Department of Examinations.

Two fifty minute examinations were administered to all students during the semester. Regularly enrolled students took these examinations in their classes. Television students (except the handicapped) reported to the college branch at which they were enrolled for all examinations.

Television students reported to their branch one hour before the regularly scheduled examination time. Here they were met by their section teacher who conducted a review session. At this time students' questions concerning the subject matter were answered. Based on the author's experi-

1 Max D. Engelhart, "Obtaining Comparable Scores on Two or More Tests," Educational and Psychological Measurement, XIX (Spring 1959), 60.
ence with these classes most of the questions at these times were concerned with a discussion of the homework exercises and detail concerning the course material. The test was administered at the end of this hour of discussion.

Television students were able to speak to Mr. Slutsky or Dr. Jerome by telephone throughout the week at either of two hours set aside by these instructors. Clarification of course material could be obtained at this time. All information concerning records and grades had to be directed to the section teacher.

The first examination was given in the middle of the sixth week of the course. The test consisted of eighty-five items on geology. The second test of eighty-five items was given in the twelfth week. The subject matter of the test was meteorology and astronomy. The Appendix includes copies of these tests.

Fifteen regular class sections of this course at the Wright Branch were taught by six instructors; five class sections were taught by four teachers at the Wilson Branch. Since all students did not meet on any one day of the week, the regular students took the hourly examinations over an interval of two days. Television students took the examinations on one of these two days specified in advance.

Both regularly enrolled and television students took the final examination on the same day. There were 185 items on the final examination. The last ten items were concerned with the topic of "heat." Since "heat" is not part of the subject matter of the course at the Wright Branch, the Wright students omitted the last ten items—176 through 185. To compare branches,
therefore, only the first 175 test items were considered in the final tabulations.

In addition to the subject matter questions all students were asked to answer five questions concerning their agreement or disagreement with statements concerning the course and science in general. The television students answered ten questions concerning their agreement or disagreement with items about the television instruction and the telecast. Results of the tabulation of these items are summarized on pages 103, 104 and 105.

The final achievement score earned by each student was obtained by totaling the student's scores on each of the two hourly examinations and the final examination. A perfect score would have been 345. These total scores are the measures used in evaluating the comparative achievements of the different groups of students.

In those cases where an instructor taught more than one section the data from the day sections were kept separate from those of the evening sections even though the instructor may have taught both a day and an evening section.

To simplify the recording of data as well as the separation of data into different categories a three by five card was prepared for each student listing the student's complete name, his section number, and the instructor's name. Beneath this other information was recorded. The squares and products of the scores which were of use in later computations were also listed on this card.
A summary card for each section was prepared listing the sums of each of these scores, squares, and products. These scores, squares, and products were then totalled for each instructor; the results of evening classes were separated. Summary sheets for the Wright data and the Wilson data are incorporated in Tables I and II in the Appendix.

If the Otis, pretest, or instructional score for an individual student were not available, the student's card was rejected for purposes of tabulation and statistical analysis.

Frequency distributions of the Otis scores, pretest scores, and final achievement scores were tallied and are reported in Tables I, II, and III. All means and standard deviations were computed from ungrouped data. These results are believed to be more accurate than those calculated from frequency distributions because of the coarseness of grouping characteristic of frequency distributions. It was also necessary to have the totals for subsequent calculations.
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One can note from Table III that TV students at both branches attained achievement scores higher than those of the evening students and materially more than those of the day students. One can conclude from this that if achievement scores of students are to be used as the criterion in assigning final grades then there should be no qualm in granting college credit to the students instructed via television.

These results support an affirmative answer to the first problem of this study posed on page 11. It should be clearly understood that these results do not justify a conclusion to the effect that television instruction is therefore superior to classroom instruction, because there may be many other factors—as the greater age with subsequent greater maturity of the TV student, possibly greater motivation on the part of the TV student, superior background of the TV student, etc.—which explain the greater achievement of the TV student. Whatever the factors involved the TV students achieve equally as well and indeed better on achievement tests and therefore deserve college credit.

The means for each instructor's classes at the Wright branch are listed in Table IV. These means were calculated using the ungrouped data from Table I of the appendix. Preceding each mean is given the rank of that instructor's classes; these are in parentheses. A rank of "(1)"., for instance, indicates that the classes of the given instructor were the highest listed in the group; a rank of "(6)" indicates that the classes of the instructor were lowest.

Considering the day students the table indicates that Instructor 2 had students who initially ranked highest on the Otis test and the pretest and ultimately highest on their achievement scores. The achievement mean score
**TABLE IV**

RANK ON OTIS, PRETEST, AND ACHIEVEMENT SCORES

WRIGHT DATA

<table>
<thead>
<tr>
<th>Teacher</th>
<th>N</th>
<th>Otis Scores</th>
<th>Pretest Scores</th>
<th>Achievement Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Sigma</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>71</td>
<td>(5)</td>
<td>47.56</td>
<td>9.66</td>
</tr>
<tr>
<td>2</td>
<td>61</td>
<td>(1)</td>
<td>51.98</td>
<td>9.82</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>(2)</td>
<td>51.10</td>
<td>12.21</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>(4)</td>
<td>49.11</td>
<td>10.39</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>(6)</td>
<td>47.20</td>
<td>10.50</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
<td>(3)</td>
<td>50.94</td>
<td>9.16</td>
</tr>
<tr>
<td><strong>Day</strong></td>
<td></td>
<td>386</td>
<td>49.46</td>
<td>10.31</td>
</tr>
<tr>
<td><strong>Evening</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>(1)</td>
<td>57.52</td>
<td>9.92</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>(3)</td>
<td>53.70</td>
<td>10.74</td>
</tr>
<tr>
<td>6</td>
<td>29</td>
<td>(2)</td>
<td>53.76</td>
<td>9.62</td>
</tr>
<tr>
<td><strong>Evening</strong></td>
<td></td>
<td>94</td>
<td>54.73</td>
<td>10.32</td>
</tr>
<tr>
<td><strong>TV</strong></td>
<td>56</td>
<td></td>
<td>57.37</td>
<td>10.40</td>
</tr>
<tr>
<td><strong>Branch</strong></td>
<td></td>
<td>536</td>
<td>51.25</td>
<td>10.74</td>
</tr>
</tbody>
</table>

*Table showing mean and standard deviation for Otis, pretest, and achievement scores for different teachers and days.*
for the classes taught by Teacher 4 was second highest; his students ranked fourth on the initial Otis test and third on the initial pretest. This indicates that his classes achieved final grades which were higher than those expected from the initial test data. Those taught by Teacher 6 showed the lowest achievement mean score, but it should be noted that his students ranked lowest on the pretest but third in initial intelligence as measured by the Otis test.

It is interesting to note that Teacher 2 had evening students who ranked first on Otis, pretest, and achievement scores; in all cases the evening scores were higher than the corresponding day student scores. Teacher 6 had evening students who initially tested higher on the Otis and pretest than did his day students; the students' achievement means are materially higher, however, than those of his day students.

One may note, in general, that the initial Otis, pretest, and the final achievement scores of the evening students are higher than those of the day students. TV students rank well on all scores.

The means on the Otis, pretest, and achievement scores for the Wilson data were calculated using the ungrouped data from Table II of the appendix. These means are listed in Table V. As in Table IV the rank of each instructor's classes are listed in parentheses preceding each score.
TABLE V
RANK ON OTIS, PRETEST, AND ACHIEVEMENT SCORES
WILSON DATA

<table>
<thead>
<tr>
<th>Teacher</th>
<th>N</th>
<th>Otis Scores</th>
<th></th>
<th>Pretest Scores</th>
<th></th>
<th>Achievement Scores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>Sigma</td>
<td>Mean</td>
<td>Sigma</td>
<td>Mean</td>
</tr>
<tr>
<td>Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>61</td>
<td>(3) 15.98</td>
<td>14.24</td>
<td>(3) 17.31</td>
<td>7.17</td>
<td>(1) 183.84</td>
<td>15.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) 47.06</td>
<td>12.56</td>
<td>(1) 18.96</td>
<td>6.67</td>
<td>(2) 183.24</td>
<td>46.06</td>
</tr>
<tr>
<td>B₁*</td>
<td>50</td>
<td>(1) 47.24</td>
<td>13.11</td>
<td>(2) 18.45</td>
<td>6.24</td>
<td>(3) 179.02</td>
<td>46.84</td>
</tr>
<tr>
<td>B₂*</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day total</td>
<td>153</td>
<td></td>
<td>16.68</td>
<td>13.41</td>
<td>18.16</td>
<td>6.80</td>
<td>182.68</td>
</tr>
<tr>
<td>Evening</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>29</td>
<td>(2) 19.14</td>
<td>11.35</td>
<td>(1) 17.48</td>
<td>7.19</td>
<td>(2) 205.97</td>
<td>50.30</td>
</tr>
<tr>
<td>D</td>
<td>34</td>
<td>(1) 50.68</td>
<td>12.14</td>
<td>(2) 15.18</td>
<td>6.64</td>
<td>(1) 206.50</td>
<td>46.86</td>
</tr>
<tr>
<td>Evening total</td>
<td>63</td>
<td>19.97</td>
<td>11.81</td>
<td>16.24</td>
<td>7.00</td>
<td>206.25</td>
<td>48.49</td>
</tr>
<tr>
<td>TV</td>
<td>86</td>
<td>57.73</td>
<td>10.31</td>
<td>23.30</td>
<td>5.29</td>
<td>222.77</td>
<td>44.39</td>
</tr>
<tr>
<td>Branch total</td>
<td>302</td>
<td>18.87</td>
<td>12.49</td>
<td>17.95</td>
<td>6.73</td>
<td>195.22</td>
<td>47.92</td>
</tr>
</tbody>
</table>

* B₁ refers to one section taught by teacher B
  B₂ refers to another section taught by same teacher

The Otis score means of the day evening, and TV students at Wilson rank in the same order as did those of the Wright students, namely the TV Otis mean is the highest and the mean of the day students the lowest. The evening pretest means are lower than those of the day students. The means of the TV students are highest. The achievement score mean is highest for TV students and lowest for day students.
At the Wright branch all instructors except Teacher 6 were experienced teachers. Teacher 6 at the time of the TV offering had had only one semester of teaching experience. He did not enjoy teaching; his colleagues rated him as a relatively poor teacher. He is no longer at the Wright Branch.

At the Wilson Branch Teachers A and D were regular teachers at the Branch. Teachers B and C were new instructors at the Branch; both had had outside teaching experience but had never taught the physical science course before. Their department chairman rated them as "very competent."
CHAPTER IV

STATISTICAL ANALYSIS OF THE DATA

ANALYSIS OF COVARIANCE

The Wright and Wilson data were separately subjected to analysis of covariance. This technique has the advantage of making it possible to compensate for any initial lack of equivalence of the groups participating in the experiment as measured by the pretest and the general aptitude or intelligence tests mentioned.

Before an analysis of variance and covariance can be made there are certain assumptions which must be satisfied. It is assumed in an analysis of variance and covariance that the population variances from which the samples have been drawn are equal; thus it is to be expected that estimates of the population variance differ only within the limits of random sampling.

Since the analysis was made separately for students at Wright and at Wilson, tests for the homogeneity of variance at each branch were made using the Bartlett test for unequal n's. In this method the test of significance

\[ F = \frac{MSE_1}{MSE_2} \]

where MSE_1 is the mean square error of the first sample and MSE_2 is the mean square error of the second sample.

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Also see E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education (Cambridge, 1953), p. 73; Palmer O. Johnson, Statistical Methods in Research (New York, 1949), p. 82.
### TABLE VI

**BARTLETT’S TEST FOR HOMOGENEITY OF VARIANCE**

**WRIGHT DATA**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>n</th>
<th>n - 1</th>
<th>(\frac{1}{n-1})</th>
<th>(\sum x^2)</th>
<th>(s^2)</th>
<th>log (s^2)</th>
<th>((n - 1)(\log s^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>71</td>
<td>70</td>
<td>0.016286</td>
<td>117,752</td>
<td>2,110.74</td>
<td>3.32613</td>
<td>232.71010</td>
</tr>
<tr>
<td>2</td>
<td>61</td>
<td>60</td>
<td>0.016667</td>
<td>115,163</td>
<td>1,919.38</td>
<td>3.28316</td>
<td>196.98960</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>29</td>
<td>0.034783</td>
<td>63,737</td>
<td>2,197.83</td>
<td>3.34199</td>
<td>96.91771</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>90</td>
<td>0.011111</td>
<td>155,039</td>
<td>1,722.66</td>
<td>3.23620</td>
<td>291.25800</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>69</td>
<td>0.01693</td>
<td>132,024</td>
<td>1,913.39</td>
<td>3.28160</td>
<td>226.19120</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
<td>62</td>
<td>0.016129</td>
<td>91,085</td>
<td>1,468.47</td>
<td>3.16686</td>
<td>196.37532</td>
</tr>
<tr>
<td><strong>Evening</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>24</td>
<td>0.016667</td>
<td>32,723</td>
<td>1,363.66</td>
<td>3.13464</td>
<td>75.23136</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>39</td>
<td>0.025621</td>
<td>79,162</td>
<td>2,029.79</td>
<td>3.30745</td>
<td>128.99055</td>
</tr>
<tr>
<td>6</td>
<td>29</td>
<td>28</td>
<td>0.035714</td>
<td>61,185</td>
<td>2,195.89</td>
<td>3.34161</td>
<td>93.56508</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>55</td>
<td>55</td>
<td>0.019011</td>
<td>163,372</td>
<td>1,899.50</td>
<td>3.27863</td>
<td>180.32465</td>
</tr>
</tbody>
</table>

**Computations:**

1. \[
\frac{\sum x^2}{\sum (n - 1)} = \frac{984,502}{526} = 1,871.677; \log 1,871.677 = 3.27224
\]

2. \[
\left[\sum (n - 1)\right] \left[\log \frac{\sum x^2}{\sum (n - 1)}\right] = 526(3.27224) = 1,721.19824
\]

3. \[
\text{Diff.} = \left[\sum (n - 1)\right] \left[\log \frac{\sum x^2}{\sum (n - 1)}\right] - \sum (n - 1)(\log s^2)
\]

\[
= 1,721.19824 - 1,718.77657 = 2.42167
\]

4. \[
\chi^2 = (2.3026)(\text{diff.}) = 2.3026(2.42167) = 5.57613
\]

From table of \(\chi^2\), using \(df = r - 1 = 9\), this gives a \(P = 0.76\).

Therefore, assumption of homogeneity of variance is accepted.
### TABLE VII

**BARTLETT'S TEST FOR HOMOGENEITY OF VARIANCE**

**WILSON DATA**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>n</th>
<th>n - 1</th>
<th>$\frac{1}{n-1}$</th>
<th>$\sum x^2$</th>
<th>$s^2$</th>
<th>$\log s^2$</th>
<th>$(n - 1)(\log s^2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>61</td>
<td>60</td>
<td>0.016666</td>
<td>126,557</td>
<td>2,109.28</td>
<td>3.32114</td>
<td>199.68840</td>
</tr>
<tr>
<td>B1</td>
<td>50</td>
<td>49</td>
<td>0.020408</td>
<td>106,089</td>
<td>2,165.06</td>
<td>3.33548</td>
<td>163.43652</td>
</tr>
<tr>
<td>B2</td>
<td>42</td>
<td>41</td>
<td>0.024390</td>
<td>92,160</td>
<td>2,217.60</td>
<td>3.35176</td>
<td>137.12216</td>
</tr>
<tr>
<td><strong>Evening</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>29</td>
<td>28</td>
<td>0.035714</td>
<td>73,369</td>
<td>2,620.32</td>
<td>3.1835</td>
<td>95.71380</td>
</tr>
<tr>
<td>D</td>
<td>33</td>
<td>32</td>
<td>0.030303</td>
<td>71,673</td>
<td>2,262.82</td>
<td>3.35164</td>
<td>110.70312</td>
</tr>
<tr>
<td><strong>TV</strong></td>
<td>86</td>
<td>85</td>
<td>0.011764</td>
<td>169,198</td>
<td>1,991.09</td>
<td>3.29975</td>
<td>280.17875</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>296</td>
<td></td>
<td></td>
<td>642,346</td>
<td></td>
<td></td>
<td>987.20475</td>
</tr>
</tbody>
</table>

**Computations:**

1. \[ \frac{\sum x^2}{\Sigma (n - 1)} = \frac{642,346}{296} = 2,170.09; \log 2,170.09 = 3.33648 \]

2. \[ \left[ \Sigma (n - 1) \right] \left[ \log \frac{\sum x^2}{\Sigma (n - 1)} \right] = 296(3.33648) = 987.59808 \]

3. \[ \text{Diff.} = \left[ \Sigma (n - 1) \right] \left[ \log \frac{\sum x^2}{\Sigma (n - 1)} \right] - \Sigma (n - 1)(\log s^2) \]
   \[ = 987.59808 - 987.20475 = 0.39333 \]

4. \[ \chi^2 = (2.3026)(\text{diff.}) = 2.3026(0.39333) = 0.90568 \]

From table of $\chi^2$, using df. = r - 1 = 5, this gives a $P = 0.97$.

Therefore, assumption of homogeneity of variance is accepted.
is made by means of $\chi^2$. The $\chi^2$ test attempts to answer the question as to how likely the variances of the measures are the same except for chance. The degrees of freedom is one less than the number of samples or $r - 1$.

In Table VI the $\chi^2$ value of $5.5761$, $df = 9$, is indicative of a $P = 0.76$. This indicates that merely as a result of chance the variances in seventy-six times out of a hundred could differ as they do. This is not regarded as significant, and therefore the assumption of homogeneity of variance for the Wright data can be accepted.

A probability of 0.97 for the Wilson data, Table VII, again justifies the acceptance of the assumption of the homogeneity of variance.\(^\text{2}\)

When the assumption of homogeneity of variance is not satisfied, experimental differences may be due to differences in the variability of the groups compared rather than to the differences in average achievement usually regarded as evidence of the comparative effectiveness of the instructional methods studied.

The analysis of covariance also assumes that there are no real differences among the group regressions. This assumption is necessary because the adjusted sum of squares for a group is measured by the sum of the squared deviations from the regression line for that group based on the common with-

\(^\text{2}\)The $L_1$ test of Welch for the Wright data also indicated that the assumption of homogeneity of variance could be accepted. The test is described by Palmer Johnson on p. 83 and pp. 231-232. On p. 85 Palmer Johnson states "that Bartlett's test would appear advantageous in comparison with the $L_1$-test when the size of the samples is much larger that $n = 60$. Since the range of the $L_1$-values is only from 0 to 1, the test is not highly sensitive."
in-groups regression coefficient.\textsuperscript{3} Thus there must be no real difference between the group regressions.

Heterogeneity of regression, i.e. significantly different regression coefficients for the compared groups, in addition to reducing the dependability of the adjustments made in the achievement means and the estimate of experimental error (the adjusted within groups variance) may indicate the compared methods vary in relative effectiveness for different levels of initial ability thus suggesting a different type of analysis such as the methods by levels design or the Johnson-Neyman technique.

The test for homogeneity of regression for the Wright and the Wilson data was made using the method described by Snedecor and by Lindquist.\textsuperscript{4} The data for these tests are summarized in Tables VIII and IX. Since the F ratios are not significant, one may conclude that the assumptions of homogeneity of regression are satisfied.

The sums of squares and products of Table VIII were calculated from the individual group data of Tables I and II of Appendix I by means of formulas of this type:

\[ \sum x_1^2 = \sum x_1^2 - \frac{(\sum x_1)^2}{n} \quad \text{where } n \text{ is size of given group} \]

\[ \sum x_1 y = \sum x_1 y - \frac{\sum x_1 \sum y}{n} \]

The following formulas were employed in calculating the regression coe-

\textsuperscript{3}Lindquist, O. 330.

\textsuperscript{4}G. W. Snedecor, Statistical Methods (Ames, 1946), pp. 325-327.

Lindquist, p. 330-331.
Regression coefficients: use data from each line

\[
b_{x_1} = \frac{\Sigma x_1 y \Sigma x_2^2 - \Sigma x_2 y \Sigma x_1 x_2}{\Sigma x_1^2 \Sigma x_2^2 - (\Sigma x_1 x_2)^2}
\]

\[
b_{x_2} = \frac{\Sigma x_2 y \Sigma x_1^2 - \Sigma x_1 y \Sigma x_1 x_2}{\Sigma x_1^2 \Sigma x_2^2 - (\Sigma x_1 x_2)^2}
\]

Errors of estimate: use regression coefficient and data in each line

\[
\Sigma' y^2 = \Sigma y^2 - b_{x_1} \Sigma x_1 y - b_{x_2} \Sigma x_2 y
\]
TABLE VIII
TEST FOR HOMOGENEITY OF REGRESSION
WRIGHT DATA

<table>
<thead>
<tr>
<th>Teacher</th>
<th>n</th>
<th>( \Sigma x_1^2 )</th>
<th>( \Sigma x_2^2 )</th>
<th>( \Sigma x_1 x_2 )</th>
<th>( \Sigma x_1 y )</th>
<th>( \Sigma x_2 y )</th>
<th>( \Sigma y^2 )</th>
<th>( b_{x_1} )</th>
<th>( b_{x_2} )</th>
<th>( \Sigma y' )</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>1</td>
<td>71</td>
<td>6,623</td>
<td>2,820</td>
<td>1,526</td>
<td>7,595</td>
<td>10,719</td>
<td>117,752</td>
<td>0.3691</td>
<td>3.6157</td>
<td>106,216</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>61</td>
<td>5,879</td>
<td>2,218</td>
<td>1,741</td>
<td>11,160</td>
<td>12,076</td>
<td>115,161</td>
<td>0.3736</td>
<td>5.1186</td>
<td>98,818</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>30</td>
<td>4,171</td>
<td>1,175</td>
<td>919</td>
<td>8,786</td>
<td>14,968</td>
<td>63,737</td>
<td>1.3185</td>
<td>3.1158</td>
<td>36,713</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>91</td>
<td>9,833</td>
<td>3,813</td>
<td>3,282</td>
<td>25,794</td>
<td>15,344</td>
<td>155,038</td>
<td>1.7960</td>
<td>2.4782</td>
<td>70,687</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>70</td>
<td>7,719</td>
<td>2,606</td>
<td>2,627</td>
<td>23,115</td>
<td>10,868</td>
<td>132,021</td>
<td>2.4637</td>
<td>1.6856</td>
<td>55,914</td>
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<tr>
<td></td>
<td>6</td>
<td>63</td>
<td>5,287</td>
<td>1,981</td>
<td>1,340</td>
<td>10,598</td>
<td>7,604</td>
<td>91,045</td>
<td>1.3378</td>
<td>2.9291</td>
<td>51,059</td>
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<tr>
<td>Evening</td>
<td>2</td>
<td>25</td>
<td>2,459</td>
<td>1,095</td>
<td>1,012</td>
<td>6,367</td>
<td>4,618</td>
<td>32,723</td>
<td>1.2842</td>
<td>3.1097</td>
<td>10,695</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>40</td>
<td>4,617</td>
<td>1,696</td>
<td>1,688</td>
<td>16,175</td>
<td>8,308</td>
<td>79,162</td>
<td>2.5872</td>
<td>2.7244</td>
<td>15,972</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>29</td>
<td>2,673</td>
<td>886</td>
<td>987</td>
<td>6,022</td>
<td>2,564</td>
<td>61,182</td>
<td>2.0119</td>
<td>0.6526</td>
<td>17,693</td>
</tr>
<tr>
<td>TV</td>
<td>56</td>
<td>6,051</td>
<td>2,316</td>
<td>2,356</td>
<td>10,409</td>
<td>8,125</td>
<td>106,372</td>
<td>0.5866</td>
<td>2.9115</td>
<td>76,615</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>536</td>
<td>55,612</td>
<td>20,111</td>
<td>17,478</td>
<td>126,551</td>
<td>85,188</td>
<td>981,496</td>
<td>1.3168</td>
<td>3.0613</td>
<td>523,412</td>
<td>506</td>
</tr>
</tbody>
</table>

d.f. = three less than number of students
Continued from Page 43

<table>
<thead>
<tr>
<th>Degrees of freedom</th>
<th>Errors of Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of squares</td>
<td>Variance</td>
</tr>
</tbody>
</table>

| Deviations from average regression within groups | 524 | 544,960 | 1,040.00 |
| Deviations from individual group regressions    | 506 | 523,442 | 1,034.47 |
| Differences among group regressions             | 18  | 21,518  | 1,195.44 |

\[ \text{d.f. for within groups variance} = N - n - 1 \]
\[ = 536 - 10 - 2 = 524 \]

\[ F = \frac{1,195.44}{1,034.47} = 1.1556, \text{ for 18 and 506 d.f.} \]

This F ratio is not significant, and the null hypothesis for homogeneity of regression is accepted.

Deviations from average regression within groups value is obtained by multiplying total \( \sum y^2 \) value from first part of table by

\[ 1 - R^2 \]

\( y \cdot x_1 \cdot x_2 \) (Table XI, page 51)

The value for individual group regressions is the total value, \( \sum' y^2 \);

from first part of table.

The value for differences among group regressions is obtained by subtracting the values listed above.
**Table IX**

**TEST FOR HOMOGENEITY OF REGRESSION**

**WILSON DATA**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>n</th>
<th>(\Sigma x_1^2)</th>
<th>(\Sigma x_2^2)</th>
<th>(\Sigma x_1x_2)</th>
<th>(\Sigma x_1y)</th>
<th>(\Sigma x_2y)</th>
<th>(\Sigma y^2)</th>
<th>(b_{x_1})</th>
<th>(b_{x_2})</th>
<th>(\Sigma y^2)</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>61</td>
<td>12,373</td>
<td>3,140</td>
<td>4,383</td>
<td>27,217</td>
<td>12,988</td>
<td>126,557</td>
<td>1.0529</td>
<td>2.1063</td>
<td>59,630</td>
<td>58</td>
</tr>
<tr>
<td>B1</td>
<td>50</td>
<td>7,893</td>
<td>2,226</td>
<td>2,868</td>
<td>15,920</td>
<td>9,626</td>
<td>106,088</td>
<td>0.8380</td>
<td>3.2617</td>
<td>61,511</td>
<td>47</td>
</tr>
<tr>
<td>B2</td>
<td>42</td>
<td>7,216</td>
<td>1,634</td>
<td>2,055</td>
<td>22,194</td>
<td>8,752</td>
<td>92,160</td>
<td>2.1514</td>
<td>2.3184</td>
<td>18,262</td>
<td>39</td>
</tr>
<tr>
<td>Evening</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>29</td>
<td>3,733</td>
<td>1,501</td>
<td>1,639</td>
<td>5,141</td>
<td>5,355</td>
<td>73,369</td>
<td>-0.2230</td>
<td>3.8111</td>
<td>54,166</td>
<td>26</td>
</tr>
<tr>
<td>D</td>
<td>34</td>
<td>2,011</td>
<td>1,499</td>
<td>1,961</td>
<td>11,221</td>
<td>6,919</td>
<td>17,673</td>
<td>0.8771</td>
<td>3.1552</td>
<td>60,813</td>
<td>31</td>
</tr>
<tr>
<td>TV</td>
<td>86</td>
<td>9,116</td>
<td>3,254</td>
<td>2,128</td>
<td>2,079</td>
<td>12,515</td>
<td>169,195</td>
<td>2.0572</td>
<td>2.5164</td>
<td>88,632</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>302</td>
<td>15,372</td>
<td>13,254</td>
<td>15,034</td>
<td>106,015</td>
<td>56,185</td>
<td>323,019</td>
<td>1.9412</td>
<td>2.5542</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- d.f. = three less than number of students

<table>
<thead>
<tr>
<th></th>
<th>Degrees of freedom</th>
<th>Errors of Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sum of squares</td>
</tr>
<tr>
<td>Deviations from average regression within groups</td>
<td>29h</td>
<td>310,883</td>
</tr>
<tr>
<td>Deviations from individual group regressions</td>
<td>28h</td>
<td>323,019</td>
</tr>
<tr>
<td>Differences among group regressions</td>
<td>10</td>
<td>17,866</td>
</tr>
</tbody>
</table>

- d.f. for within groups variance = \(N - n - 1\) where \(N\) = total number of students
- \(n\) = number of groups
- \(i\) = number of initial tests

\[ F = \frac{1786.1/1137.3}{1.5707}, \text{for 10 and 28h d.f.} \]

This \(F\) ratio is not significant, and the null hypothesis of homogeneity of regression is accepted.
A non-significant $F$ is necessary in order to satisfy the basic assumption of homogeneity of regression. One may accept the assumption if $F$ is non-significant below the 10% level.

A significant $F$ would indicate that the effectiveness of the compared methods is related to the ability levels of the students as measured by the initial tests. This would then suggest further study using the methods $x$ levels design or the Johnson-Neyman technique.\(^5\)

The logic of the $F$ test here may be more clear if one thinks of regression lines rather than the regression planes involved where there are three variables. Visualize lines for each group and an average regression line for all groups. According to the theory of least squares if one considers a single line for one of the groups, the summation of squared deviations from this line will be less than the summation of squared deviations of the same points from any other line including the average regression line. Thus the summation of all the squared deviations from their respective group regression lines will be less than the sum from the average regression line. If all of the group lines are similar in direction or slope to the average regression line, the "differences among group regressions", the difference just referred

\(^5\) It is interesting to note that when the $L_1$-criterion to test the hypothesis of homogeneity of regression is checked according to the method described by Palmer Johnson on page 259 the hypothesis of homogeneity of regression for the Wright data must be rejected at the 1% level and the hypothesis of homogeneity of regression for the Wilson data must be rejected at the 5% level. Since Palmer Johnson admits that the $L_1$-test, with the $L_1$-value ranging from zero to one, is not highly sensitive, it is felt that the acceptance of the hypothesis of homogeneity of regression is justified.
to, will be smaller than if the directions or slopes are markedly different, thus leading to a smaller and possible non-significant F.

The term "errors of estimate" has the same meaning as in the more typical use of regression equations. The usual standard error of estimate is the standard deviation of the deviates from a regression line (the square root of the sum of squares of the deviates or errors of estimate from the regression line divided by N); this is more easily computed from the appropriate standard deviation and correlation or multiple correlation coefficient.

Since the data satisfied the fundamental assumptions of homogeneity of variance and homogeneity of regression, an analysis of covariance, with the Otis scores and pretest scores as the initial variables, was made.

The data necessary for an analysis of covariance were compiled from the summary card of each student. The totals for each score, for the square of each score, and for the products of any two scores were summed for each instructor within each group—day, evening, and TV—at the Wright and Wilson branches. Day, evening, and branch totals were also computed.

The sums of squares and of products for the different sources of variation were computed as follows:

The sums of squares and products for total, for between groups, and for within groups were computed from the appropriate data of Table VIII and IX by means of the equations listed below. The symbol $X_1$ refers to Otis scores, $X_2$ to pretest scores, and $Y$ to achievement scores. Where no other subscript is given summation is over all N scores. Where

---

6 See page 28 of Chapter III.
the subscripts a, b, etc. appear summation is over the scores of a given group.

For total:

\[ \Sigma x_1^2 = \Sigma x_1^2 - \frac{(\Sigma x_1)^2}{N} \]

\[ \Sigma x_2^2 = \Sigma x_2^2 - \frac{(\Sigma x_2)^2}{N} \]

\[ \Sigma y_2 = \Sigma y^2 - \frac{(\Sigma y)^2}{N} \]

\[ \Sigma x_1 x_2 = \Sigma x_1 x_2 - \frac{\Sigma x_1 \Sigma x_2}{N} \]

\[ \Sigma x_1 y = \Sigma x_1 y - \frac{\Sigma x_1 \Sigma y}{N} \]

\[ \Sigma x_2 y = \Sigma x_2 y - \frac{\Sigma x_2 \Sigma y}{N} \]

For between groups

\[ \Sigma x_1^2 = \frac{(\Sigma x_{1a})^2}{N_a} + \frac{(\Sigma x_{1b})^2}{N_b} + \ldots + - \frac{(\Sigma x_1)^2}{N} \]

(Dots refer to terms for other groups)

\[ \Sigma x_2^2 = \frac{(\Sigma x_{2a})^2}{N_a} + \frac{(\Sigma x_{2b})^2}{N_b} + \ldots + - \frac{(\Sigma x_2)^2}{N} \]

\[ \Sigma y^2 = \frac{(\Sigma y_{a})^2}{N_a} + \frac{(\Sigma y_{b})^2}{N_b} + \ldots + - \frac{(\Sigma y)^2}{N} \]

\[ \Sigma x_1 x_2 = \frac{\Sigma x_{1a} \Sigma x_{2a}}{N_a} + \frac{\Sigma x_{1b} \Sigma x_{2b}}{N_b} + \ldots + - \frac{\Sigma x_1 \Sigma x_2}{N} \]

\[ \Sigma x_1 y = \frac{\Sigma x_{1a} \Sigma y_{a}}{N_a} + \frac{\Sigma x_{1b} \Sigma y_{b}}{N_b} + \ldots + - \frac{\Sigma x_1 \Sigma y}{N} \]
\[
\sum x_2y = \frac{\sum x_2 \sum y_a}{N_a} + \frac{\sum x_2 \sum y_b}{N_b} + \ldots + \frac{\sum x_2 \sum y}{N}
\]

For within groups \(\sum x_1^2\), \(\sum x_2^2\), \(\sum y^2\), \(\sum x_1x_2\), \(\sum x_1y\), \(\sum x_2y\) was obtained by subtracting the computed between value from the computed total value.

To afford a check on the accuracy of the calculations the within groups sums of squares and products were computed using the equations

\[
\sum x_1^2 = \sum x_1^2 - \left[ \frac{(\sum x_1)^2}{N_a} + \frac{(\sum x_1)^2}{N_b} + \ldots \right]
\]

\[
\sum x_2^2 = \sum x_2^2 - \left[ \frac{(\sum x_2)^2}{N_a} + \frac{(\sum x_2)^2}{N_b} + \ldots \right]
\]

\[
\sum y^2 = \sum y^2 - \left[ \frac{(\sum y)^2}{N_a} + \frac{(\sum y)^2}{N_b} + \ldots \right]
\]

\[
\sum x_1x_2 = \sum x_1x_2 - \left[ \frac{\sum x_1 \sum x_2}{N_a} + \frac{\sum x_1 \sum x_2}{N_b} + \ldots \right]
\]

\[
\sum x_1y = \sum x_1y - \left[ \frac{\sum x_1 \sum y_a}{N_a} + \frac{\sum x_1 \sum y_b}{N_b} + \ldots \right]
\]

\[
\sum x_2y = \sum x_2y - \left[ \frac{\sum x_2 \sum y_a}{N_a} + \frac{\sum x_2 \sum y_b}{N_b} + \ldots \right]
\]

The data for the Wright branch are summarized in Table X.
TABLE X
Sums of Squares and Products
Wright Data

<table>
<thead>
<tr>
<th></th>
<th>$\sum x_1^2$</th>
<th>$\sum x_2^2$</th>
<th>$\sum x_1 x_2$</th>
<th>$\sum x_1 y$</th>
<th>$\sum x_2 y$</th>
<th>$\sum y^2$</th>
<th>Adjusted or reduced sum of squares $\frac{\sum y^2}{\chi^2}$</th>
<th>d.f.</th>
<th>Adjusted or reduced variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>6,222</td>
<td>1,990</td>
<td>2,867</td>
<td>23,137</td>
<td>11,123</td>
<td>12,199</td>
<td>1,1,779.66</td>
<td>9</td>
<td>1,462.18</td>
</tr>
<tr>
<td>Within groups</td>
<td>55,611</td>
<td>20,407</td>
<td>17,177</td>
<td>126,548</td>
<td>85,188</td>
<td>98,499</td>
<td>5,86,963.51</td>
<td>92</td>
<td>1,060,00</td>
</tr>
<tr>
<td>Total</td>
<td>61,833</td>
<td>22,397</td>
<td>26,344</td>
<td>119,685</td>
<td>99,311</td>
<td>1,109,493</td>
<td>5,86,763.17</td>
<td>52</td>
<td>1,060,00</td>
</tr>
</tbody>
</table>

$F = \frac{\text{reduced between}}{\text{adjusted within}} = \frac{1,462.18}{1,060.00} = 1.41636$

d.f. for between groups = number of groups - 1 = 10 - 1 = 9

d.f. for within groups = $N - n - i$ where $N$ is total number of students

= 536 - 10 - 2 = $n$ number of groups

= 52 = $i$ number of initial tests

Since the $F$ value exceeds the 1% level value$^7$ of 2.4538, the $F$ test is concluded to be significant at the 1% level.

$^7$See any standard statistical tables for the distribution of $F$. For example see J. P. Guilford, Fundamental Statistics in Psychology and Education (New York, 1956), pp. 51-52.
The adjusted or reduced sum of square data of Table X were obtained by calculating the Pearson product-moment correlation coefficient from the total group and the within groups data. From these the multiple coefficients of correlation, \( R \), for the total group and the within groups data were computed. The adjusted or reduced sum of squares column of Table X was obtained by multiplying the appropriate original \( \Sigma y^2 \) value for the total group by one minus the square of the total multiple coefficient \( R \) and the \( \Sigma y^2 \) value for the within groups by one minus the square of the within multiple coefficient.

The correlation coefficients for the Wright data are summarised in Table XI.

The adjusted or reduced variance is obtained by dividing the adjusted or reduced sum of squares by the appropriate degrees of freedom.

Since the F ratio is significant at the 1% level, adjusted total score means were computed for each teacher's class using regression coefficients based on the within groups data. The adjusted mean is equal to the original mean minus a correction for the initial Otis test score minus a correction for the initial pretest score. This correction, \( c_1 \) and \( c_2 \), was obtained by

<table>
<thead>
<tr>
<th></th>
<th>( r_{x_1 x_2} )</th>
<th>( r_{x_1 y} )</th>
<th>( r_{x_2 y} )</th>
<th>( R_{y \cdot x_1 x_2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total groups</strong></td>
<td>0.5467</td>
<td>0.5726</td>
<td>0.6300</td>
<td>0.6864</td>
</tr>
<tr>
<td><strong>Within groups</strong></td>
<td>0.5188</td>
<td>0.5408</td>
<td>0.5866</td>
<td>0.6682</td>
</tr>
</tbody>
</table>
multiplying the regression coefficients $b_{x_1}$ (for the Otis test scores) and $b_{x_2}$ (for the pretest scores) by the difference between the original mean and the grand mean where

$$b_{x_1} = \frac{\sum x_1 y \sum x_2^2 - \sum x_2 y \sum x_1 x_2}{\sum x_1^2 \sum x_2^2 - (\sum x_1 x_2)^2}$$

$$b_{x_2} = \frac{\sum x_2 y \sum x_1^2 - \sum x_1 y \sum x_1 x_2}{\sum x_1^2 \sum x_2^2 - (\sum x_1 x_2)^2}$$

Where the Otis and pretest means of a group are above the general means this results in a lowered adjusted achievement mean. Conversely, where the Otis and pretest means are lower than the general means this results in a higher adjusted achievement mean.

Table XII lists the Otis test score correction factors and the pretest score correction factors.

Using the adjusted achievement score means of Table XII, t tests of the difference between adjusted means were computed using Wishart's formula for the error of a difference. The formula used is

$$\sigma_{\text{diff}} = \sqrt{V(0 + \frac{N_a + N_b}{N_a N_b})}$$

where $V = \text{adjusted within groups variance}$

$$V = \frac{(\sum_{1a}^{x_1} - \sum_{1b}^{x_1})^2 \sum_{1} x_1^2 - 2(\sum_{1a}^{x_2} - \sum_{1b}^{x_2})(\sum_{1a}^{x_1} - \sum_{1b}^{x_1}) \sum_{2a} x_1 x_2 + (\sum_{1a}^{x_2} - \sum_{1b}^{x_2})^2 \sum_{2a} x_2^2}{\sum x_1^2 \sum x_2^2 - (\sum x_1 x_2)^2}$$

and $N_a$ and $N_b$ are the sizes of groups a and b respectively.

---

### Table XII

**Adjusted Achievement Score Means**

**Wright Data**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>N</th>
<th>Otis Score</th>
<th>Pretest Score</th>
<th>Achievement Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean $X_1$</td>
<td>Mean $X_2$</td>
<td>Mean $X_3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difference between mean and grand mean</td>
<td>Difference between mean and grand mean</td>
<td>Difference between mean and grand mean</td>
</tr>
<tr>
<td>Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>71</td>
<td>17.56</td>
<td>-3.69*</td>
<td>18.92</td>
</tr>
<tr>
<td>2</td>
<td>61</td>
<td>51.98</td>
<td>+0.73</td>
<td>19.64</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>51.10</td>
<td>-0.15</td>
<td>17.77</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>19.12</td>
<td>-1.81</td>
<td>17.85</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>17.20</td>
<td>-1.05</td>
<td>17.66</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
<td>50.91</td>
<td>-0.31</td>
<td>17.33</td>
</tr>
<tr>
<td>Day total</td>
<td>386</td>
<td>49.16</td>
<td>-1.79</td>
<td>18.20</td>
</tr>
<tr>
<td>Evening</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>57.52</td>
<td>+6.27</td>
<td>23.12</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>53.70</td>
<td>+2.55</td>
<td>19.58</td>
</tr>
<tr>
<td>6</td>
<td>29</td>
<td>53.76</td>
<td>+2.51</td>
<td>16.17</td>
</tr>
<tr>
<td>Evening total</td>
<td>94</td>
<td>51.73</td>
<td>+3.48</td>
<td>20.08</td>
</tr>
<tr>
<td>TV</td>
<td>56</td>
<td>57.73</td>
<td>+6.48</td>
<td>23.30</td>
</tr>
<tr>
<td>Grand total</td>
<td>536</td>
<td>51.25</td>
<td>19.18</td>
<td>222.77</td>
</tr>
</tbody>
</table>

* Negative sign indicates that mean is less than grand mean.
* Positive sign indicates that mean is more than grand mean.

$b_{x_1} = 1.3186$  
$b_{x_2} = 3.6452$
Using this standard error of the difference between the adjusted means, a t test of this difference was computed. The computed t was compared for significance with standard t tables using degrees of freedom = N₁ + N₂ - 2.

The results of these t test computations are summarized below:

**Significant at 5% level**

Teacher 1: over Teacher 6 (day)
Teacher 4: over Teacher 5
over Teacher 6 (day)
Teacher 3 (evening): over Teacher 5
Teacher 6 (evening): over Teacher 5

**Significant at 1% level**

Teacher 2 (day): over Teacher 5 (almost significant at 1% level)
over Teacher 6 (day)
Teacher 4 (day): over Teacher 6 (day)
Teacher 2 (evening): over Teacher 5
over Teacher 6 (day)
Teacher 3 (evening): over Teacher 6 (day)
Teacher 6 (evening): over Teacher 6 (day)
TV: over Teacher 6 (day)

In attempting to interpret these results one should keep in mind that Teacher 6 was an inexperienced teacher recently appointed; Teacher 5 was a teacher of many years experience who had been teaching the course for a few

---

9 See any standard statistical tables for t ratios significant at the .05 level and at the .01 level. For example see Guilford, p. 539.

10 Palmer Johnson, p. 47; also Guilford, p. 220.
years; Teacher 4 was a teacher of only a few years teaching experience. The other teachers, 1, 2, and 3, were experienced teachers.

It is interesting to note that the newly appointed teacher's classes were the only ones to differ significantly at the 1% level in favor of TV. The evening class of this instructor achieved significantly more than his day classes. This would seem to imply that factors other than the inexperience of the teacher are involved.

Though the classes of one experienced teacher did not differ significantly from the achievement of the TV students, the achievement of his classes differed significantly at the 1% and 5% level, from the achievements of other experienced teachers.

The significant F can be attributed to the differences just described rather than to differences between classroom instruction and TV instruction. Thus these differences were among the classes taught by different teachers rather than between TV and control classes. The F test is merely an overall test indicating significant differences among some of the comparisons.

To illustrate further that differences were not due to real differences between the day students, the evening students, and the TV students an analysis of covariance of the combined day scores, combined evening scores, and the TV scores was made according to the method just described.

Data for the sums of squares and products of the combined day, combined evening, and TV scores are given in Table XIII while the correlation coefficients necessary to calculate the adjusted or reduced sum of squares column of Table XIII are given in Table XIV.
### TABLE XIII

**SUMS OF SQUARES AND PRODUCTS OF COMBINED DAY, EVENING, AND TV SCORES**

**WEIGHT DATA**

<table>
<thead>
<tr>
<th></th>
<th>$\sum x_1^2$</th>
<th>$\sum x_2^2$</th>
<th>$\sum x_1x_2$</th>
<th>$\sum x_1y$</th>
<th>$\sum x_2y$</th>
<th>$\sum y^2$</th>
<th>Adjusted or reduced sum of squares</th>
<th>Adjusted or reduced variance</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>1,737</td>
<td>1,392</td>
<td>2,170</td>
<td>19,090</td>
<td>9,700</td>
<td>77,580</td>
<td>8,461</td>
<td>1,230.5</td>
<td>2</td>
</tr>
<tr>
<td>Within groups</td>
<td>57,096</td>
<td>21,005</td>
<td>17,870</td>
<td>130,895</td>
<td>89,607</td>
<td>1,031,909</td>
<td>578,282</td>
<td>1,223.52</td>
<td>531</td>
</tr>
<tr>
<td>Total</td>
<td>61,833</td>
<td>22,397</td>
<td>20,340</td>
<td>149,985</td>
<td>99,311</td>
<td>1,109,493</td>
<td>666,743</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**d.f.** for between groups = number of groups - 1 = 3 - 1 = 2  
**d.f.** for within groups = $N - n - 1$ where $N$ is total number of students  
= 536 - 3 - 2  
n is number of groups  
= 531  
i is number of initial tests

The $F$ is significant at the 5% level but not at the 1% level.

$$F = \frac{\text{reduced between}}{\text{adjusted within}} = \frac{1,230.50}{1,089.00} = 3.6846$$

### TABLE XIV

**CORRELATION COEFFICIENTS OF COMBINED DAY, EVENING, AND TV SCORES**

**WEIGHT DATA**

<table>
<thead>
<tr>
<th></th>
<th>$r_{x_1x_2}$</th>
<th>$r_{x_1y}$</th>
<th>$r_{x_2y}$</th>
<th>$r_{y,x_1x_2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total groups</td>
<td>0.5167</td>
<td>0.5726</td>
<td>0.6300</td>
<td>0.6666</td>
</tr>
<tr>
<td>Within groups</td>
<td>0.5161</td>
<td>0.5393</td>
<td>0.6086</td>
<td>0.6630</td>
</tr>
</tbody>
</table>
**TABLE XV**

ADJUSTED TOTAL ACHIEVEMENT SCORE MEANS
WRIGHT DATA

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean ( x_1 )</th>
<th>Difference between mean and grand mean</th>
<th>Mean ( x_2 )</th>
<th>Difference between mean and grand mean</th>
<th>Achievement mean</th>
<th>Adjusted mean = original mean (-a_1 -a_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day total</td>
<td>366</td>
<td>49.66</td>
<td>-1.79*</td>
<td>18.20</td>
<td>-1.26*</td>
<td>191.30</td>
<td>197.59</td>
</tr>
<tr>
<td>Evening total</td>
<td>44</td>
<td>54.73</td>
<td>+3.68</td>
<td>20.08</td>
<td>+0.68</td>
<td>211.76</td>
<td>208.20</td>
</tr>
<tr>
<td>TV</td>
<td>56</td>
<td>57.73</td>
<td>+6.48</td>
<td>23.30</td>
<td>+3.86</td>
<td>222.77</td>
<td>202.14</td>
</tr>
<tr>
<td>Grand total</td>
<td>536</td>
<td>51.25</td>
<td></td>
<td>19.18</td>
<td></td>
<td>202.27</td>
<td></td>
</tr>
</tbody>
</table>

* Negative sign indicates that mean is less than grand mean
  Positive sign indicates that mean is more than grand mean

\( b_{x_1} = +1.3046 \)
\( b_{x_2} = +3.1558 \)

Since the F ratio is significant at the 5% level, adjusted total score means were computed for the total day, total evening, and TV as described on page 51. Following this, t-tests of the difference between adjusted means were computed using Wishart's formula for the error of a difference as described on page 52.
Results of the t test computations indicate that there are no differences between the day totals and TV and the evening totals and TV; there is a difference at the 5% level, however, favoring the evening totals over the day totals.

These results would again seem to imply that there are no differences between methods involved since the evening classes were taught by instructors who also taught some of the day sections. Assuming that the instruction in the evening classes was therefore not much different from that in the day classes, one would conclude that the population of the evening classes is probably different from that of the day classes.

The superiority of achievement of evening students of the Chicago City Junior College over that of the day students has long been known. It is entirely possible that the superior achievement of the evening students may be attributed to such factors as greater age with possibly better background, greater interest, and greater motivation.

The data at the Wilson Branch of the Chicago City Junior College were similarly analyzed. Distributions of Otis scores, Pretest scores, and Achievement scores are previously given in Tables I, II, and III respectively. Table VII summarises the data for Bartlett's test for homogeneity of variance, the test indicating that the assumption of homogeneity of variance may be accepted. The assumption of homogeneity of regression is accepted; the summary of these data is given in Table IX. The total Wilson population was 302.

The summary of covariance data closely approximates that of the Wright Branch.\textsuperscript{11}

\textsuperscript{11}See Table X and XI.
### TABLE XVI

**SUMS OF SQUARES AND PRODUCTS**

**WILSON DATA**

<table>
<thead>
<tr>
<th></th>
<th>$\Sigma x_1^2$</th>
<th>$\Sigma x_2^2$</th>
<th>$\Sigma x_1 x_2$</th>
<th>$\Sigma x_1 y$</th>
<th>$\Sigma x_2 y$</th>
<th>$\Sigma y^2$</th>
<th>$\Sigma' y^2$</th>
<th>Adjusted or reduced sum of squares</th>
<th>d.f.</th>
<th>Adjusted or reduced variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>1,727</td>
<td>1.21</td>
<td>50</td>
<td>8,627</td>
<td>-587</td>
<td>51,231</td>
<td>32,539</td>
<td>5</td>
<td>6,507.80</td>
<td></td>
</tr>
<tr>
<td>Within groups</td>
<td>15,372</td>
<td>13,254</td>
<td>15,034</td>
<td>106,015</td>
<td>56,185</td>
<td>61,231</td>
<td>340,883</td>
<td>294</td>
<td>1,063.52</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17,099</td>
<td>13,675</td>
<td>15,084</td>
<td>111,042</td>
<td>55,558</td>
<td>693,577</td>
<td>373,422</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F = \text{reduced between} \frac{\text{adjusted within}}{\text{1,063.52}} = 6.1191

d.f. for between groups = number of groups - 1 = 6 - 1 = 5

d.f. for within groups = N - n - i, where N is total number of students
= 302 - 6 - 2 = 294

The F value suggests that there are differences in the final means which are significant beyond the 1% level.

### TABLE XVII

**CORRELATION COEFFICIENTS**

**WILSON DATA**

<table>
<thead>
<tr>
<th></th>
<th>$r_{x1x2}$</th>
<th>$r_{x1y}$</th>
<th>$r_{x2y}$</th>
<th>$r_{y,x1x2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total groups</td>
<td>0.5944</td>
<td>0.6356</td>
<td>0.5709</td>
<td>0.6791</td>
</tr>
<tr>
<td>Within groups</td>
<td>0.6131</td>
<td>0.6212</td>
<td>0.6089</td>
<td>0.7026</td>
</tr>
</tbody>
</table>
The correlation coefficients necessary to calculate the adjusted or reduced sum of square data of Table XVI are given in Table XVII.

Since the F ratio was significant beyond the 1% level, adjusted achievement means were computed for all classes and the total day, total evening, and TV as previously described. Wishart's formula for the error of a difference was used to compute t test of the difference between adjusted means.

Results of the t test computations indicate that there are no differences between the day totals and TV; there are differences, however, which favor evening totals over day totals at the 1% level and evening totals over TV at the 5% level.

These results seem to imply that there are probably little differences between methods involved and that the population of the evening classes is probably different from that of the day classes.

Differences between individual sections were also checked for significance. The sections which indicate that there are differences between the means are as follows:

**Significant at the 5% level**

Section C over section A
- D over TV
- TV over B₂

**Significant at the 1% level**

Section C over section B₁
- C over B₂
- D over A
- D over B₁
- D over B₂
| Teacher | N | Mean $x_1$ | Difference between mean and grand mean | $c_1 \times x_1$ | Mean $x_2$ | Difference between mean and grand mean | $c_2 \times x_2$ | Achievement mean | Adjusted mean = original mean $-c_1 - c_2$
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>61</td>
<td>15.98</td>
<td>-2.89*</td>
<td>-4.3182</td>
<td>17.31</td>
<td>-0.61</td>
<td>-1.6281</td>
<td>183.69</td>
<td>189.79</td>
</tr>
<tr>
<td>B_1</td>
<td>50</td>
<td>17.06</td>
<td>-1.81</td>
<td>-2.70.5</td>
<td>18.96</td>
<td>+1.01</td>
<td>+2.5696</td>
<td>183.24</td>
<td>183.37</td>
</tr>
<tr>
<td>B_2</td>
<td>42</td>
<td>17.24</td>
<td>-1.63</td>
<td>-2.4355</td>
<td>18.45</td>
<td>+0.50</td>
<td>+1.2721</td>
<td>179.62</td>
<td>180.79</td>
</tr>
<tr>
<td>Day total</td>
<td>153</td>
<td>16.68</td>
<td>-2.19</td>
<td>-3.2723</td>
<td>18.16</td>
<td>+0.21</td>
<td>+0.5311</td>
<td>182.18</td>
<td>185.22</td>
</tr>
<tr>
<td>Evening</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>29</td>
<td>19.11</td>
<td>+0.27</td>
<td>+0.403</td>
<td>17.18</td>
<td>-0.47</td>
<td>-1.1958</td>
<td>205.97</td>
<td>206.77</td>
</tr>
<tr>
<td>D</td>
<td>31</td>
<td>50.68</td>
<td>+1.81</td>
<td>+2.70.5</td>
<td>15.18</td>
<td>-2.77</td>
<td>-7.0171</td>
<td>206.50</td>
<td>210.85</td>
</tr>
<tr>
<td>Evening total</td>
<td>63</td>
<td>19.97</td>
<td>+1.10</td>
<td>+1.6436</td>
<td>16.24</td>
<td>-1.71</td>
<td>-4.3506</td>
<td>206.25</td>
<td>208.96</td>
</tr>
<tr>
<td>TV</td>
<td>86</td>
<td>57.73</td>
<td>+8.86</td>
<td>+13.2386</td>
<td>23.30</td>
<td>+5.35</td>
<td>+13.6115</td>
<td>222.77</td>
<td>195.92</td>
</tr>
<tr>
<td>Grand total</td>
<td>302</td>
<td>18.87</td>
<td></td>
<td>17.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>195.22</td>
</tr>
</tbody>
</table>

* Negative sign indicates that mean is less than grand mean

Positive sign indicates that mean is more than grand mean

$\frac{b_{x_1}}{2} = 1.6912$  
$\frac{b_{x_2}}{2} = 2.5412$
The results again seem to substantiate the conclusion that the evening population is different from the day since both evening sections are significant over the day sections at the 1% level (except that section C exceeds section A at the 5% level). It is only the better evening section, D, that exceeds TV at the 5% level; TV, however, exceeds the poorest day section, B₂, at the 5% level.

It should be noted that Teacher B (who taught two day sections) and Teacher C (who taught one of the evening sections) were new instructors at the Branch. They had never taught the physical science course before, but they had had outside teaching experience and were rated by their department chairman as "very competent."
CHAPTER V

STATISTICAL ANALYSIS OF THE DATA

METHODS BY LEVELS ANALYSIS OF VARIANCE

The Wright and Wilson data were subjected to methods by levels analysis of variance. The method, essentially, is an application of the analysis of variance technique to groups which have been matched on the basis of some initial test score. Its advantage over the classic matched group technique is that it provides a means of determining whether or not the relative effectiveness of the compared methods of instruction is related to the initial levels of ability of the students. In the present case methods by levels analyses were made first with the Wright data alone and then with the Wright and Wilson data combined using frequency distributions of the Otis intelligence scores matched for day, evening, and TV groups. Similar analyses were then made using frequency distributions of matched pretest scores.

In the present analysis all day data from Wright and Wilson were combined in order to increase the number of cases in each group; so were the evening and TV data from both branches. Samples were drawn from these combined data. The samples were chosen so that groups at various intelligence levels were obtained, each of these groups having been matched as closely as possible on the basis of the initial Otis intelligence score. Consideration was also
given in the matching process to choose samples from each branch, preferably
from various instructors, and—where there were many more samples at the in-
telligence level than were needed—to the pretest score. Thus, if one needed
three samples of day Otis score h3 to match with the three evening Otis score
h3 samples but five day Otis score h3 samples were available, other criterion
having been satisfied the three day samples chosen from the five had pretest
scores most nearly comparable to the three evening sample pretest scores.

Since an Otis score of h2 corresponds to an IQ of 100, it was decided to
group, if possible, the data with scores below an IQ of 100 (Otis scores of
h1 and down) and above an IQ of 100 (Otis scores of h2 and up). Thus, the
levels ultimately used represented IQ intervals of 99 down, 100 – 109, 110 –
119, and 120 and up.

Distributions of scores were prepared by arranging the 3 x 5 cards of
each student's data in order of decreasing Otis score and then choosing the
intervals as randomly as possible from the cards. The data for the methods
x levels analysis of variance of the combined Wright day, evening, and TV
scores are summarized in Table XIX.

The items in each cell of the main part of Table XIX contain data rele-
vant to the cases of the given group in the given class interval (intelligence
level) as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>d</td>
</tr>
<tr>
<td>b</td>
<td>e</td>
</tr>
<tr>
<td>c</td>
<td>f</td>
</tr>
</tbody>
</table>

a. The number of cases, n
b. The sum of the final scores, ΣY
c. The sum of the squares of the final
   scores, ΣY²
<table>
<thead>
<tr>
<th>Initial score level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>62 up</td>
<td>20, 720</td>
<td>236,00</td>
<td>26,316,900</td>
<td>22,791,076</td>
</tr>
<tr>
<td></td>
<td>1,131,920.00</td>
<td>1,313,053</td>
<td>1,315,815.00</td>
<td>1,188,330</td>
</tr>
<tr>
<td></td>
<td>1,139,53.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52-61</td>
<td>16, 11,451.56</td>
<td>13,168,900</td>
<td>12,215,025</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,381</td>
<td>211.50</td>
<td>3,670</td>
<td>229.38</td>
</tr>
<tr>
<td></td>
<td>730,512</td>
<td>715,716.00</td>
<td>869,610</td>
<td>861,006.25</td>
</tr>
<tr>
<td></td>
<td>763,439.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42-51</td>
<td>12, 751,396</td>
<td>11,618,201</td>
<td>5,769,604</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,086</td>
<td>173.83</td>
<td>2,119</td>
<td>179.08</td>
</tr>
<tr>
<td></td>
<td>381,088</td>
<td>362,616.33</td>
<td>361,850.08</td>
<td>180,800.33</td>
</tr>
<tr>
<td>51 down</td>
<td>1, 131,261</td>
<td>1,556,516</td>
<td>729,316</td>
<td></td>
</tr>
<tr>
<td></td>
<td>659</td>
<td>164.75</td>
<td>716</td>
<td>186.50</td>
</tr>
<tr>
<td></td>
<td>112,275</td>
<td>108,576.25</td>
<td>139,150</td>
<td>139,129.00</td>
</tr>
<tr>
<td></td>
<td>282,329.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 down</td>
<td>52, 117,700.801</td>
<td>136,773.025</td>
<td>132,825,625</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20, 819</td>
<td>2,263,776.98</td>
<td>2,630,250.18</td>
<td>11,525</td>
</tr>
<tr>
<td></td>
<td>156, 1,160,696,761</td>
<td>2,558,338.94</td>
<td>34,069</td>
<td>7,110,363.85</td>
</tr>
</tbody>
</table>
d. The square of the sum of the final scores, \((\Sigma Y)^2\)

e. The cell mean, \(\mu\), which equals \(\frac{\Sigma Y}{n}\) or \(b \div a\)

f. The square of the sum of final scores divided by \(n\),
\[(\Sigma Y)^2 \div n\) or \(d \div a\)

In the cells of the column headed "All groups" the following data were
computed from data in the cells of that row:

<table>
<thead>
<tr>
<th>g</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td>h</td>
<td>j</td>
</tr>
</tbody>
</table>

g. The total number of cases in row,
\[n_{day} + n_{evening} + n_{TV} = n_i\]

h. The sum of the final scores in
that row \(= \Sigma \Sigma Y_i\)

i. The square of the sum of final scores
in that row \(= (\Sigma \Sigma Y_i)^2 = h^2\)

j. The square of the sum of final scores in that row divided
by number of cases in row \((\Sigma \Sigma Y_i)^2 \div n_i = i \div g\)

The cells at the bottom of each column contain data computed from data
in the cells of that column:

<table>
<thead>
<tr>
<th>k</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>l</td>
<td>n</td>
</tr>
</tbody>
</table>

k. The total number of cases in column,
\[n_{day} + n_{evening} + n_{TV} = n_j\]

l. The sum of the final scores in that column \(= \Sigma \Sigma Y_j\)

m. The square of the sum of final scores in that column \(= (\Sigma \Sigma Y_j)^2 = l^2\)

n. The square of the sum of final scores in that row divided
by number of cases in column \(= (\Sigma \Sigma Y_j)^2 \div n_j = m \div k\)

The cell at the bottom of the column headed "All groups" contains similar
data:
o. Sum of n's in this column is the total number of cases, N.

p. The total sum of the sums of the final scores in each row = $\sum Y$

q. The square of the total sum of the sums of the final scores in each row = $(\sum Y)^2 = p^2$

r. The square of the total sum of the sums of the final scores in each row $\frac{1}{N} \sum Y = (\sum Y)^2 \frac{1}{N} = q \frac{1}{N}$

Computations, based on the table, were made as follows:

$A = r$ from lowest cell of right-hand column of table

$B = \sum c$ scores from each cell

$C = \sum f$ scores from each cell

$D = \sum j$ scores from each cell of "All groups" column

$E = \sum n$ scores from total columns cells

$SS_T$ = sums of squares total

$SS_L$ = sums of squares of levels

$SS_M$ = sums of squares of methods

$SS_{cells}$ = sums of squares of cells

$SS_{ML}$ = sums of squares of methods by levels

$SS_{W}$ = sums of squares within subgroups

$B - A$ = $SS_T$

$D - A$ = $SS_L$

$E - A$ = $SS_M$

$C - A$ = $SS_{cells}$

$SS_{ML} = SS_{cells} - SS_M - SS_L$

$SS_{W} = SS_T - SS_{cells}$
TABLE XX
SUMS OF SQUARES OF METHODS x LEVELS ANALYSIS OF VARIANCE
WRIGHT DATA
OTIS SCORES MATCHED

<table>
<thead>
<tr>
<th></th>
<th>Sums of squares</th>
<th>Degrees of freedom</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>7,702.51</td>
<td>(M - 1)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,851.13</td>
</tr>
<tr>
<td>Levels</td>
<td>91,215.88</td>
<td>(L - 1)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30,405.29</td>
</tr>
<tr>
<td>Cells</td>
<td>108,211.25</td>
<td>(ML - 1)</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methods x levels</td>
<td>9,292.86</td>
<td>(M - 1) x</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(L - 1)</td>
<td>1,548.81</td>
</tr>
<tr>
<td>Within sub-groups</td>
<td>170,799.90</td>
<td>(N - ML)</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,186.11</td>
</tr>
<tr>
<td>Total</td>
<td>279,011.15</td>
<td>(N - 1)</td>
<td>155</td>
</tr>
</tbody>
</table>

\[ F_{\text{methods}} = \frac{3,851.13}{1,186.11} = 3.2469 \]
\[ F_{\text{M x L}} = \frac{1,548.81}{1,186.11} = 1.3058 \]

From tables for 2 and 144 d.f.,
F is significant at 5% level
From tables for 6 and 144 d.f.,
F is non-significant

Since an F value for methods was obtained which was significant at the 5% level, a t test for the differences between means was made to see where differences occurred. To do this the standard t formula for the difference between two means was utilized:

\[ t = \frac{M_1 - M_2}{\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \]
where \( \sigma_{\text{diff.}} = \sqrt{V \left( \frac{1}{n_1} + \frac{1}{n_2} \right)} \).

\( V \) is the within sub-groups variance

and \( n \) refers to the number of cases in each of the two cells on the same level.

Actually substitutions were made in the equation and the equation was solved to indicate what difference in means was necessary to obtain significance at the 5% level. For example for the 62 up level, using 2 and 144 d.f., a value of \( t \) of 1.9767 is required for significance at the 5% level. From Table XX the variance, \( V \), is 1,186.11. The \( n \) value of each cell is 20. Substituting into the \( t \) equation above,

\[
1.9767 = \frac{M_1 - M_2}{\sqrt{1,186.11 \left( \frac{1}{20} + \frac{1}{20} \right)}}
\]

Solving for \( M_1 - M_2 \), a value of 21.5302 is required to give a difference between means which would be significant at the 5% level. Since there are no differences this large between the day, evening, and TV means, it is concluded that there are no differences in method between the day, evening, and TV groups at the 62 up level.

No significant differences between means were obtained for the 52—61 level and for the 42—51 level. However for the 41 down level, the difference between the TV and day mean was 48.75 which was significant at the 5% level since the \( t \) test indicated that a difference between means of 48.139 would be significant at the 5% level. It should be noted, however, that the number of cases in each cell at this level was only 4. This number of cases is so low that one cannot draw a valid conclusion to the effect that the TV
students in the 41 down level achieve significantly more than the day students in this category.

In order to increase the number of cases in each group the Wright and Wilson data were combined as described above, and a methods by levels analysis of variance computation for the combined data was made. The essential data for these computations are summarized in Table XXI. It should be noted that there were insufficient evening cases to match all cells at each level with the day and TV scores. As a result all the cells in the evening groups contain three-fourths as many cases as do the day and TV groups.

Table XXII gives the sums of squares of methods x levels analysis of variance for the Wright and Wilson data combined; the data are based on a matching of the initial Otis scores.

Since an F value significant at the 5% level was obtained for methods, t tests for the differences between means were made. For the degrees of freedom listed, a t value of 1.967 is significant at the 5% level and a t of 2.590 is significant at the 1% level.

The t test indicated a significant difference at the 5% level favoring evening instruction over day instruction for the Otis h2—51 level. In all other comparisons there were no significant differences between the means.

The results of the methods by levels analysis of variance with the Otis scores matched would seem to imply that the interaction variance was not significant. When one considers the differences between the total day, the total evening, and the total TV means, it was interesting to observe that the total day mean (with the Otis scores matched) differed from the total evening mean at the 5% level in favor of the evening instruction, and the total day mean
TABLE XXI
METRICS BY LEVELS: ANALYSIS OF VARIANCE
WRIGHT AND WILSON DATA COMBINED
OTIS SCORES MATCHED

<table>
<thead>
<tr>
<th>Initial score level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>62 up</td>
<td>1.0</td>
<td>90.592,321</td>
<td>1.0</td>
<td>95.199,019</td>
</tr>
<tr>
<td></td>
<td>9.511</td>
<td>237.95</td>
<td>9.757</td>
<td>20.392</td>
</tr>
<tr>
<td></td>
<td>2.301,166</td>
<td>2.26,108.10</td>
<td>2.66,727</td>
<td>2.379,976.22</td>
</tr>
<tr>
<td>52-61</td>
<td>1.0</td>
<td>72.982,619</td>
<td>1.0</td>
<td>77.915,929</td>
</tr>
<tr>
<td></td>
<td>8.543</td>
<td>213.58</td>
<td>8.827</td>
<td>220.68</td>
</tr>
<tr>
<td></td>
<td>1.673,677</td>
<td>1.82,571.22</td>
<td>1.98,136.1</td>
<td>1.98,698.22</td>
</tr>
<tr>
<td>1.2-51</td>
<td>36</td>
<td>62,012.256</td>
<td>36</td>
<td>50,011.476</td>
</tr>
<tr>
<td></td>
<td>6.1,81</td>
<td>186.11</td>
<td>7.073</td>
<td>196.50</td>
</tr>
<tr>
<td></td>
<td>1.226,762</td>
<td>1.16,010.11</td>
<td>1.13,003</td>
<td>1.39,011.0</td>
</tr>
<tr>
<td>0-1.1</td>
<td>20</td>
<td>61,617.361</td>
<td>20</td>
<td>13,019,556</td>
</tr>
<tr>
<td></td>
<td>3,1,12</td>
<td>172.10</td>
<td>3,666</td>
<td>183.30</td>
</tr>
<tr>
<td></td>
<td>613,333</td>
<td>592,368.20</td>
<td>697,862</td>
<td>671,977.80</td>
</tr>
<tr>
<td></td>
<td>136</td>
<td>783,272.169</td>
<td>136</td>
<td>859,869.76</td>
</tr>
<tr>
<td></td>
<td>27,987</td>
<td>5,759,351.8</td>
<td>29,321</td>
<td>6,322,771.88</td>
</tr>
<tr>
<td></td>
<td>205.78</td>
<td>217.51</td>
<td>215.62</td>
<td></td>
</tr>
</tbody>
</table>

Means
TABLE XXII

SUMS OF SQUARES OF METHODS X LEVELS ANALYSIS OF VARIANCE
WRIGHT AND WILSON DATA COMBINED
OTIS SCORES MATCHED

<table>
<thead>
<tr>
<th></th>
<th>Sums of squares</th>
<th>Degrees of freedom</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>10,039.55</td>
<td>(M - 1)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5,019.78</td>
</tr>
<tr>
<td>Levels</td>
<td>234,589.81</td>
<td>(L - 1)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78,196.60</td>
</tr>
<tr>
<td>Cells</td>
<td>249,568.91</td>
<td>(ML - 1)</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methods x levels</td>
<td>4,939.55</td>
<td>(M - 1) x (L - 1)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>823.26</td>
</tr>
<tr>
<td>Within sub-groups</td>
<td>475,365.92</td>
<td>(N - ML)</td>
<td>362</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,313.17</td>
</tr>
<tr>
<td>Total</td>
<td>974,503.72</td>
<td>(N - 1)</td>
<td>373</td>
</tr>
</tbody>
</table>

\[ F_{\text{methods}} = \frac{5,019.78}{1,313.17} = 3.8226 \]
\[ F_{M \times L} = \frac{823.26}{1,313.17} = 0.6269 \]

From tables for 2 and 362 d.f., \( F \) is significant at 5% level
From tables for 6 and 362 d.f., \( F \) is non-significant

also differed from the TV mean at the 5% level in favor of TV instruction.
These results would seem to imply that the relative merit of the different
types of instruction is not related to the intelligence levels of the students
as measured by the Otis test. Thus, one cannot conclude that one method of
instruction is better for superior students while less able students benefit
more from another kind of instruction. The non-significant interaction is
also evidence of homogeneity of regression.

A methods by levels analysis of variance of the combined Wright and
Wilson data with initial pretest scores matched was also made. The data
cards were matched in five groups according to the initial pretest score giving primary consideration to the pretest score. An attempt was also made to insure that cases were representative of each branch and different instructors in each branch. Final consideration in matching was the Otis score (as described on page 63).

A summary of the data for the analysis with frequency distributions of pretest scores matched is given in Table XXIII. Table XXIV summarizes the sums of squares of the methods x levels analysis of variance for the Wright and Wilson data combined based on frequency distributions of matched pretest scores.

Since a F value significant at the 1% level was obtained for methods, t tests for the differences between means were made. For the degrees of freedom listed, a t value of 1.967 is significant at the 5% level and a t of 2.589 is significant at the 1% level.

At the two lowest levels the day means differed from the TV means at the 5% and 1% level respectively in favor of the TV group. At the lowest level there was also a significant difference between the day and evening groups at the 1% level favoring the evening group.

A t test on the difference in methods for the total day, total evening, and total TV showed that the total day mean differed from the total evening mean and total TV mean at the 1% level favoring the evening and TV groups. No significant difference was found between the total evening and the total TV means. This would seem to support the inference that there is probably a difference in the populations involved in each group, since both the
<table>
<thead>
<tr>
<th>Initial score level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>11,112,211</td>
<td>13</td>
<td>12,186,100</td>
</tr>
<tr>
<td></td>
<td>3,338</td>
<td>256.77</td>
<td>3,190</td>
<td>266.16</td>
</tr>
<tr>
<td></td>
<td>868,390</td>
<td>857,095.69</td>
<td>949,333</td>
<td>936,930.76</td>
</tr>
<tr>
<td>25--29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>21,022,125</td>
<td>20</td>
<td>21,171,081</td>
</tr>
<tr>
<td></td>
<td>4,585</td>
<td>229.25</td>
<td>4,634</td>
<td>231.70</td>
</tr>
<tr>
<td></td>
<td>1,071,793</td>
<td>1,053,111.25</td>
<td>1,235,522.05</td>
<td>1,161,168</td>
</tr>
<tr>
<td>20--24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>33,851,011</td>
<td>26</td>
<td>33,570,136</td>
</tr>
<tr>
<td></td>
<td>5,821</td>
<td>223.88</td>
<td>5,794</td>
<td>222.85</td>
</tr>
<tr>
<td></td>
<td>1,330,983</td>
<td>1,303,232.24</td>
<td>1,291,170.62</td>
<td>1,208.23</td>
</tr>
<tr>
<td>15--19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>47,866,400</td>
<td>37</td>
<td>52,707,600</td>
</tr>
<tr>
<td></td>
<td>8,920</td>
<td>187.03</td>
<td>7,260</td>
<td>196.22</td>
</tr>
<tr>
<td></td>
<td>1,322,158</td>
<td>1,294,227.03</td>
<td>1,427,418.73</td>
<td>1,601,252</td>
</tr>
<tr>
<td>8--11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>11,115,556</td>
<td>21</td>
<td>16,096,211</td>
</tr>
<tr>
<td></td>
<td>3,333</td>
<td>159.76</td>
<td>4,012</td>
<td>191.05</td>
</tr>
<tr>
<td></td>
<td>555,066</td>
<td>529,312.19</td>
<td>782,156</td>
<td>766,833.01</td>
</tr>
<tr>
<td>6--1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>117</td>
<td>575,904,000</td>
<td>117</td>
<td>651,527,729</td>
</tr>
<tr>
<td></td>
<td>23,998</td>
<td>412,256.11</td>
<td>25,527</td>
<td>5,569,667.77</td>
</tr>
<tr>
<td>Means</td>
<td>205.11</td>
<td>218.18</td>
<td>215.38</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE XXIV

SUMS OF SQUARES OF METHODS x LEVELS ANALYSIS OF VARIANCE  
WRIGHT AND WILSON DATA COMBINED  
PRETEST SCORES MATCHED

<table>
<thead>
<tr>
<th></th>
<th>Sums of squares</th>
<th>Degrees of freedom</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>11,076.43</td>
<td>(M - 1) 2</td>
<td>5,538.22</td>
</tr>
<tr>
<td>Levels</td>
<td>253,367.20</td>
<td>(L - 1) 4</td>
<td>63,341.80</td>
</tr>
<tr>
<td>Cells</td>
<td>280,233.99</td>
<td>(ML - 1) 14</td>
<td></td>
</tr>
<tr>
<td>Methods x levels</td>
<td>15,790.36</td>
<td>(M - 1) x (L - 1) 8</td>
<td>1,973.80</td>
</tr>
<tr>
<td>Within sub-groups</td>
<td>376,960.68</td>
<td>(N - ML) 336</td>
<td>1,121.91</td>
</tr>
<tr>
<td>Total</td>
<td>657,194.67</td>
<td>(N - 1) 350</td>
<td></td>
</tr>
</tbody>
</table>

\[ F_{\text{methods}} = \frac{5,538.22}{1,121.91} = 4.9364 \]

\[ F_{M \times L} = \frac{1,973.80}{1,121.91} = 1.7593 \]

From tables for 2 and 336 d.f., \( F \) is significant beyond the 1% level  
From tables for 8 and 336 d.f., \( F \) is non-significant

evening and the TV groups were composed of more mature and probably better motivated individuals.
CHAPTER VI

AN ANALYSIS OF THE TEST ITEM RESPONSES

The first six items of the fifty-six item pretest consisted of questions concerning the students' background, their age, the number of courses in which they were enrolled, and the approximate number of hours the student was employed each week. The test papers of those students used in the methods by levels groups matched on the basis of the pretest scores were rescored for these six items. There were 117 students in each of the day, the evening, and the TV groups. The percents of students in each group are listed following each item response.

The item responses reveal that the high school training in science and mathematics is greatest for the day students; the formal training of the TV students in these fields is least. It is surprising, however, to note that the formal college instruction in science is greatest for the TV students with the formal college training being least for the evening group. It is also interesting to note that though there was no "E" response to the second question concerning college science training, fewer day students indicated an E answer while 2.6% and 6.8% of the evening and TV students indicated this answer choice.

The student day population is proportionately under 20 years of age with almost 18% between 20 to 24 years of age. Almost 68% of the evening population
### TABLE XXV
PERCENT OF RESPONSE TO PRETEST ITEMS

<table>
<thead>
<tr>
<th></th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. I have had</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. high school general science.</td>
<td>83.8%</td>
<td>76.1%</td>
<td>70.1%</td>
</tr>
<tr>
<td>B. high school biology, zoology, or botany.</td>
<td>53.0</td>
<td>48.7</td>
<td>53.0</td>
</tr>
<tr>
<td>C. high school chemistry.</td>
<td>48.7</td>
<td>37.6</td>
<td>26.5</td>
</tr>
<tr>
<td>D. high school physics.</td>
<td>47.0</td>
<td>39.3</td>
<td>23.1</td>
</tr>
<tr>
<td>E. none of the above.</td>
<td>0</td>
<td>5.1</td>
<td>9.4</td>
</tr>
</tbody>
</table>

| **2. I have had** |      |         |      |
| A. college biology, zoology, or botany. | 53.0   | 38.5    | 53.0  |
| B. college chemistry. | 9.4    | 10.3    | 10.3  |
| C. college physics. | 1.7    | 1.7     | 3.4   |
| D. none of the above courses. | 37.6   | 55.6    | 32.5  |
| E. (this answer choice did not appear on test) | 0.9    | 2.6     | 6.8   |

| **3. I have had** |      |         |      |
| A. elementary algebra. | 92.3   | 83.8    | 75.2  |
| B. elementary plane geometry. | 75.2   | 65.0    | 58.1  |
| C. advanced algebra. | 32.5   | 33.3    | 26.5  |
| D. solid geometry and/or trigonometry. | 29.1   | 29.1    | 18.8  |
| E. none of the above courses. | 4.3    | 6.8     | 14.5  |

| **4. I am** |      |         |      |
| A. under 20 years of age. | 77.8   | 15.2    | 4.2   |
| B. 20 to 24 years of age. | 17.9   | 28.8    | 7.6   |
| C. 25 to 29 years of age. | 2.6    | 39.8    | 18.6  |
| D. 30 to 39 years of age. | 0.9    | 11.9    | 40.7  |
| E. 40 or over 40 years of age. | 0.9    | 4.2     | 28.3  |

| **5. I am enrolled in** |      |         |      |
| A. no other course. | 2.6    | 9.4     | 9.4   |
| B. one other course. | 1.7    | 32.5    | 42.7  |
| C. two other courses. | 4.6    | 41.9    | 22.2  |
| D. three other courses. | 9.4    | 6.8     | 19.7  |
| E. four other courses, or more. | 83.8   | 9.4     | 6.0   |

| **6. In addition to being enrolled as a regular or TV student, I am** |      |         |      |
| A. a housewife and not employed. | 0.9    | 3.4     | 44.2  |
| B. not working or working less than 5 hours per week. | 35.1   | 4.2     | 2.5   |
TABLE XXV
PERCENT OF RESPONSE TO PRETEST ITEMS

<table>
<thead>
<tr>
<th>C. working 5 to 10 hours per week.</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.0%</td>
<td>0.8%</td>
<td>5.0%</td>
</tr>
<tr>
<td>D. working 10 to 20 hours per week.</td>
<td>36.8</td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>E. working over 20 hours per week.</td>
<td>20.2</td>
<td>37.3</td>
<td>43.3</td>
</tr>
</tbody>
</table>

are between 20 to 29 years of age. The greatest part of the TV population is between 30 to 39 years of age with almost 29% being 40 or over 40 years of age. It can thus be seen that the average evening student is older than the average day student. But the oldest students are those in the TV group.

In general almost 84% of the day population is carrying a full college program of five or more courses with another 9% taking four courses. The evening students (about 74%) are carrying a lighter load consisting of two or three courses. About 43% of the TV students are carrying two courses with 22% and 20% carrying three and four courses respectively.

About one-third of the day students do not work although another third works 10 to 20 hours per week; 20% work over 20 hours per week. Most of the evening students (87%) work over 20 hours per week. It is interesting to observe that 44% of the TV students are housewives and 43% work over 20 hours per week.

One can conclude that the evening and TV students are older and thus probably more motivated than the day students as indicated by their larger work-load. The oldest students are the TV students with this group containing the largest number of housewives.
In an attempt to learn something about the relative achievement of various groups on different kinds of exercises Mr. Slutsky was asked to state the objectives of the Physical Science 101 course as he saw them. The objectives as he stated them follow:

Objectives in Physical Science 101

1. To acquaint the student with certain principles in Physical Science and to introduce the pertinent facts necessary to the development of such principles.

2. To illustrate the methods of science and to develop a critical objective attitude.

3. To cultivate a point of view and a philosophy toward natural phenomena.

4. To develop an understanding of the scientist, his goals and his motivations.

5. To correlate certain scientific principles with the intellectual, social and industrial problems of our day.

The fifty items on the Physical Science Pretest and the one hundred and seventy five items on the final examination were classified by the combined efforts of Mr. Slutsky, Dr. Henrietta Freud (a chemist), Mr. Forest Etheredge (a geologist), and the author as belonging to one of three categories. In many cases these teachers experienced difficulty in agreeing upon the classification of certain few exercises.

Category 1 included those test items concerned with facts, definitions, and recognition. Those test items concerned with the application of principles were placed in Category 2; Category 3 included the test items dealing with
critical thinking and interpretation. On the pretest there were twelve test items in Category 1, twenty-three test items in Category 2, and fifteen test items in Category 3. The final examination contained seventy-one items in Category 1, eighty-seven items in Category 2, and seventeen items in Category 3.

The population used in the item analysis was that used in the methods by levels analysis of variance based on matched pretest scores as described in Chapter V. These day, evening, and TV scores were divided into upper and lower groups. The upper fifty percent of the scores comprised the upper group, while the lower fifty percent comprised the lower group. The number of cases in each group follows:

<table>
<thead>
<tr>
<th></th>
<th>High group</th>
<th>Low group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Evening</td>
<td>59</td>
<td>58</td>
</tr>
<tr>
<td>TV</td>
<td>59</td>
<td>58</td>
</tr>
</tbody>
</table>

The percent change of each of these groups was calculated for each category of items using the pretest item score and the same item score on the final examination where the pretest items were repeated. One thus could see the relative change in responses which occurred after the semester of instruction in the physical sciences. The results are listed in Table XXVII.

It is interesting to observe from the results of Table XXVII that the students in the lower half attained greater percent gains, in general, than those in the upper half of the group. The only exception is in Category 1, Facts, Definitions, and Recognition, where the day high group averaged a 0.5% gain over the Day low group. In some cases the gains of the lower group were
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Gain in</td>
<td>Initial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>average</td>
<td>average</td>
<td>average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
</tr>
<tr>
<td>Category 1</td>
<td>Upper</td>
<td>51.17</td>
<td>79.17</td>
<td>25.00</td>
<td>55.25</td>
</tr>
<tr>
<td>Facts, Definitions Recognition (12 items)</td>
<td>Lower</td>
<td>26.50</td>
<td>63.00</td>
<td>24.50</td>
<td>35.63</td>
</tr>
<tr>
<td></td>
<td>Total group</td>
<td>16.34</td>
<td>72.08</td>
<td>21.75</td>
<td>45.51</td>
</tr>
<tr>
<td>Category 2</td>
<td>Upper</td>
<td>52.13</td>
<td>72.26</td>
<td>20.13</td>
<td>51.13</td>
</tr>
<tr>
<td>Application of Principles (23 items)</td>
<td>Lower</td>
<td>30.13</td>
<td>58.91</td>
<td>21.78</td>
<td>29.17</td>
</tr>
<tr>
<td></td>
<td>Total group</td>
<td>11.13</td>
<td>63.59</td>
<td>22.46</td>
<td>12.15</td>
</tr>
<tr>
<td>Category 3</td>
<td>Upper</td>
<td>53.67</td>
<td>61.87</td>
<td>18.00</td>
<td>47.33</td>
</tr>
<tr>
<td>Critical Thinking and Interpretation (15 items)</td>
<td>Lower</td>
<td>22.80</td>
<td>45.20</td>
<td>22.16</td>
<td>21.80</td>
</tr>
<tr>
<td></td>
<td>Total group</td>
<td>33.33</td>
<td>53.53</td>
<td>20.20</td>
<td>33.57</td>
</tr>
<tr>
<td>Total</td>
<td>Upper</td>
<td>50.11</td>
<td>70.80</td>
<td>20.66</td>
<td>51.00</td>
</tr>
<tr>
<td>(50 items)</td>
<td>Lower</td>
<td>29.94</td>
<td>53.94</td>
<td>24.00</td>
<td>29.76</td>
</tr>
<tr>
<td></td>
<td>Total group</td>
<td>10.04</td>
<td>62.37</td>
<td>22.33</td>
<td>10.39</td>
</tr>
</tbody>
</table>
TABLE XXVII
PRETEST VS. FINAL EXAMINATION ITEM ANALYSIS
PERCENT GAIN IN CORRECT RESPONSES

Category 1: Facts, Definitions, Recognition

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Pretest</th>
<th>Final</th>
<th>High Day</th>
<th>High Evening</th>
<th>High TV</th>
<th>Low Day</th>
<th>Low Evening</th>
<th>Low TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.6</td>
<td>6.8</td>
<td>*-2</td>
<td>1</td>
<td>7</td>
<td>12</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>2.9</td>
<td>2.9</td>
<td>3.3</td>
<td>3.5</td>
<td>3.0</td>
<td>4.8</td>
<td>3.3</td>
<td>5.0</td>
</tr>
<tr>
<td>21</td>
<td>2.7</td>
<td>2.7</td>
<td>3.3</td>
<td>2.5</td>
<td>3.0</td>
<td>4.2</td>
<td>3.2</td>
<td>2.2</td>
</tr>
<tr>
<td>23</td>
<td>3.1</td>
<td>3.1</td>
<td>3.9</td>
<td>3.9</td>
<td>3.9</td>
<td>3.3</td>
<td>4.0</td>
<td>1.9</td>
</tr>
<tr>
<td>27</td>
<td>8.1</td>
<td>8.1</td>
<td>2.7</td>
<td>2.3</td>
<td>1.7</td>
<td>1.9</td>
<td>5.2</td>
<td>2.2</td>
</tr>
<tr>
<td>28</td>
<td>8.2</td>
<td>8.2</td>
<td>1.1</td>
<td>3.0</td>
<td>0.0</td>
<td>1.1</td>
<td>2.3</td>
<td>3.8</td>
</tr>
<tr>
<td>29</td>
<td>8.3</td>
<td>8.3</td>
<td>2.4</td>
<td>1.7</td>
<td>2.0</td>
<td>2.6</td>
<td>3.6</td>
<td>4.2</td>
</tr>
<tr>
<td>30</td>
<td>8.4</td>
<td>8.4</td>
<td>2.4</td>
<td>2.0</td>
<td>9.0</td>
<td>1.2</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>34</td>
<td>6.7</td>
<td>6.7</td>
<td>2.9</td>
<td>1.7</td>
<td>1.7</td>
<td>2.8</td>
<td>3.6</td>
<td>4.3</td>
</tr>
<tr>
<td>37</td>
<td>2.8</td>
<td>2.8</td>
<td>2.5</td>
<td>1.9</td>
<td>2.2</td>
<td>2.0</td>
<td>5.0</td>
<td>4.2</td>
</tr>
<tr>
<td>39</td>
<td>9.6</td>
<td>9.6</td>
<td>3.1</td>
<td>6.0</td>
<td>1.7</td>
<td>2.4</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>44</td>
<td>10.1</td>
<td>10.1</td>
<td>2.6</td>
<td>1.1</td>
<td>4.2</td>
<td>2.9</td>
<td>4.8</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Average gain: 25.00 23.00 19.17 24.50 32.67 30.33

Total average gain (12 items): Day: 24.75 Evening: 27.83 TV: 24.75

*A negative sign (-) indicates that there was a lower percent of responses on the final examination than on the initial pretest.
### Category 2: Application of Principles

<table>
<thead>
<tr>
<th>Item Number</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pretest</strong></td>
<td><strong>Final</strong></td>
<td><strong>Day</strong></td>
</tr>
<tr>
<td>12</td>
<td>170</td>
<td>17</td>
</tr>
<tr>
<td>13</td>
<td>169</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>171</td>
<td>38</td>
</tr>
<tr>
<td>16</td>
<td>115</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>131</td>
<td>-6</td>
</tr>
<tr>
<td>18</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>19</td>
<td>25</td>
<td>47</td>
</tr>
<tr>
<td>22</td>
<td>30</td>
<td>63</td>
</tr>
<tr>
<td>25</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>26</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>31</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>32</td>
<td>65</td>
<td>25</td>
</tr>
<tr>
<td>33</td>
<td>66</td>
<td>10</td>
</tr>
<tr>
<td>35</td>
<td>62</td>
<td>-2</td>
</tr>
<tr>
<td>36</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>38</td>
<td>95</td>
<td>17</td>
</tr>
<tr>
<td>42</td>
<td>99</td>
<td>19</td>
</tr>
<tr>
<td>43</td>
<td>100</td>
<td>21</td>
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<tr>
<td>45</td>
<td>102</td>
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<tr>
<td>46</td>
<td>172</td>
<td>14</td>
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<tr>
<td>47</td>
<td>173</td>
<td>16</td>
</tr>
<tr>
<td>48</td>
<td>174</td>
<td>17</td>
</tr>
<tr>
<td>49</td>
<td>175</td>
<td>19</td>
</tr>
</tbody>
</table>

**Average gain**

<table>
<thead>
<tr>
<th><strong>Day</strong></th>
<th><strong>Evening</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>20.13</td>
<td>23.09</td>
<td>21.78</td>
</tr>
</tbody>
</table>

**Total average gain**

<table>
<thead>
<tr>
<th><strong>Day</strong></th>
<th><strong>Evening</strong></th>
<th><strong>TV</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>22.46</td>
<td>26.50</td>
<td>21.63</td>
</tr>
</tbody>
</table>
### Category 3: Critical Thinking

<table>
<thead>
<tr>
<th>Item Number</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Evening</td>
</tr>
<tr>
<td>Pretest</td>
<td>Final</td>
<td>Day</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>-5</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>21</td>
<td>18</td>
<td>55</td>
</tr>
<tr>
<td>40</td>
<td>97</td>
<td>33</td>
</tr>
<tr>
<td>41</td>
<td>98</td>
<td>-7</td>
</tr>
<tr>
<td>50</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>51</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>52</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>53</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>54</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>55</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>56</td>
<td>11</td>
<td>31</td>
</tr>
</tbody>
</table>

#### Average gain

- High: 18.00
- Day: 20.47
- Evening: 11.40
- TV: 20.10
- Low: 22.10
- Evening: 23.73
- TV: 22.17

#### Total average gain (15 items)

- Day: 20.20
- Evening: 22.10
- TV: 16.93

Il% higher than those of the corresponding upper group. In all cases the percent gains of the evening lower group were the highest.

It is interesting to note that in Category 1 the upper day group achieved 2% lower on one item on the post-test than they originally answered on the pretest; the corresponding lower day group attained a 12% gain on this item. The upper TV group attained the same percent of correct responses on the
post-test as they did on the pretest showing, therefore, no increase in correct responses.

In exercises on the Application of Principles, Category 2, the upper group showed a decrease in percent of correct responses on six items (two for day, one for evening, and three for TV) with no change on three items (one item each for day, evening, and TV). On one item the TV lower group showed no percent gain; this corresponded with the no gain results of the upper TV group on this same item and with a 6% decrease on this item for the upper day group. In another item the upper day group decreased 2% in correct responses while there was no change on that same item in the upper evening group.

The percent gain in correct responses in Category 3 on Critical Thinking showed the lowest percent change in each of the six groups (three upper and three lower). The upper group showed a decrease in percent responses four times with no gain twice; the lower group showed a decrease three times with no gain once.

The over-all gains of the evening group in all categories is possible evidence of the population differences of this group, or this may be evidence of greater class drill in the evening group because of more rapid class coverage of routine matters leaving more time for drill and discussion.

The results of Table XXVIII indicate that the evening students again achieved a total percent correct response over the day and TV groups; one should note however that the lower evening group attained a very slightly lower correct response (0.03%) than the lower TV group.

The three largest differences in Table XXVIII were tested for significance by means of the t test. The standard error of the difference in
## TABLE XXVIII

**PHYSICAL SCIENCE 101 FINAL EXAMINATION ITEM ANALYSIS**  
**PERCENT CORRECT RESPONSES BY GROUP AND LEVEL**  
**GROUPS MATCHED ON PRETEST SCORES**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Group Level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Facts, Definitions</td>
<td>Upper</td>
<td>67.11</td>
<td>70.76</td>
<td>68.12</td>
<td>68.77</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>53.08</td>
<td>56.32</td>
<td>56.84</td>
<td>55.12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>60.10</td>
<td>63.54</td>
<td>62.63</td>
<td>62.09</td>
</tr>
<tr>
<td>Recognition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(71 items)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Application of Principles</td>
<td>Upper</td>
<td>62.91</td>
<td>63.94</td>
<td>61.66</td>
<td>62.84</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>47.14</td>
<td>50.64</td>
<td>50.40</td>
<td>49.41</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>55.04</td>
<td>57.30</td>
<td>56.03</td>
<td>56.12</td>
</tr>
<tr>
<td>(87 items)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Critical Thinking</td>
<td>Upper</td>
<td>61.71</td>
<td>61.59</td>
<td>56.76</td>
<td>60.02</td>
</tr>
<tr>
<td>and Interpretation</td>
<td>Lower</td>
<td>44.76</td>
<td>47.76</td>
<td>47.12</td>
<td>46.55</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>53.24</td>
<td>51.68</td>
<td>51.94</td>
<td>53.28</td>
</tr>
<tr>
<td>(17 items)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Upper</td>
<td>64.50</td>
<td>66.18</td>
<td>63.93</td>
<td>64.97</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>49.34</td>
<td>52.67</td>
<td>52.70</td>
<td>51.57</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>56.92</td>
<td>59.58</td>
<td>58.31</td>
<td>58.27</td>
</tr>
<tr>
<td>(175 items)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent correct was computed using a formula applicable to matched groups which takes into account the correlation between the initial scores used in matching and the final measures of achievement. These differences were non-significant.

A methods by levels analysis of variance based on matched pretest scores was made. The method used is the same as that described in Chapter V. Data for Category 1, Facts, Definitions, and Recognition, are incorporated in Tables XXIX and XXX.
## Table XXIX

**Methods X Levels Analysis of Variance**

**Pretest Scores Matched**

**Category 1: Facts, Definitions, and Recognition**

<table>
<thead>
<tr>
<th>Initial score level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 up</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>822</td>
<td>817</td>
<td>805</td>
<td>2,999</td>
</tr>
<tr>
<td></td>
<td>53,094</td>
<td>52,355</td>
<td>52,253</td>
<td>153,157,33</td>
</tr>
<tr>
<td>25--29</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>1,177</td>
<td>1,158</td>
<td>1,122</td>
<td>11,229,201</td>
</tr>
<tr>
<td></td>
<td>53,33</td>
<td>57,852.05</td>
<td>65,112</td>
<td>187,153,33</td>
</tr>
<tr>
<td>20--24</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>1,795,609</td>
<td>1,806,336</td>
<td>1,522,756</td>
<td>15,350,721</td>
</tr>
<tr>
<td></td>
<td>51,51</td>
<td>51,69</td>
<td>67,68,920</td>
<td>196,804,1h</td>
</tr>
<tr>
<td>15--19</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>2,550,409</td>
<td>2,725,861</td>
<td>2,917,26h</td>
<td>21,561,936</td>
</tr>
<tr>
<td></td>
<td>1,597</td>
<td>1,651</td>
<td>1,708</td>
<td>1,956</td>
</tr>
<tr>
<td></td>
<td>68,929.77</td>
<td>73,325</td>
<td>83,07h</td>
<td>221,278.03</td>
</tr>
<tr>
<td>8--11</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>589,82h</td>
<td>801,025</td>
<td>78h,996</td>
<td>6,197,401</td>
</tr>
<tr>
<td></td>
<td>34,57</td>
<td>42,62</td>
<td>42,19</td>
<td>2,549</td>
</tr>
<tr>
<td></td>
<td>28,086.57</td>
<td>38,18h,05</td>
<td>37,380.76</td>
<td>103,133,3h</td>
</tr>
<tr>
<td>5--8</td>
<td>117</td>
<td>117</td>
<td>117</td>
<td>351</td>
</tr>
<tr>
<td></td>
<td>31,337,604</td>
<td>34,392,325</td>
<td>33,120,025</td>
<td>296,59,52h</td>
</tr>
<tr>
<td></td>
<td>5,598</td>
<td>5,865</td>
<td>5,755</td>
<td>8,9,61,80</td>
</tr>
</tbody>
</table>

*Note: The above table includes data for different initial score levels, days, evenings, and TV scores, along with corresponding total scores for all groups.*
**TABLE XXX**

SUMS OF SQUARES OF METHODS x LEVELS ANALYSIS OF VARIANCE
PRETEST SCORES MATCHED
CATEGORY 1: FACTS, DEFINITIONS, AND RECOGNITION

<table>
<thead>
<tr>
<th></th>
<th>Sums of Squares</th>
<th>Degrees of Freedom</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>307.42</td>
<td>$(M - 1)$</td>
<td>2</td>
</tr>
<tr>
<td>Levels</td>
<td>16,911.77</td>
<td>$(L - 1)$</td>
<td>4</td>
</tr>
<tr>
<td>Cells</td>
<td>18,558.68</td>
<td>$(ML - 1)$</td>
<td>11</td>
</tr>
<tr>
<td>Methods x Levels</td>
<td>1,339.49</td>
<td>$(M - 1) \times (L - 1)$</td>
<td>8</td>
</tr>
<tr>
<td>Within sub-groups</td>
<td>34,522.92</td>
<td>$(N - ML)$</td>
<td>336</td>
</tr>
<tr>
<td>Total</td>
<td>53,081.60</td>
<td>$(N - 1)$</td>
<td>350</td>
</tr>
</tbody>
</table>

\[
F_{\text{methods}} = \frac{153.71}{102.75} = 1.4960
\]

\[
F_{M \times L} = \frac{167.44}{102.75} = 1.6296
\]

From tables for 2 and 336 d.f.,
\[
F \text{ is non-significant.}
\]

From tables for 8 and 336 d.f.,
\[
F \text{ is non-significant.}
\]

Thus, there are no differences at any level.

The data for Category 2, Recognition and Application of Principles, are incorporated in Tables XXXI and XXXII while the data for Category 3, Critical Thinking, appear in Tables XXXIII and XXXIV.
<table>
<thead>
<tr>
<th>Initial score level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>39</td>
</tr>
<tr>
<td>30 up</td>
<td>700</td>
<td>736</td>
<td>692</td>
<td>2,128</td>
</tr>
<tr>
<td></td>
<td>38,078</td>
<td>42,266</td>
<td>37,900</td>
<td>116,112.10</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>25--29</td>
<td>9,1</td>
<td>1,031</td>
<td>1,009</td>
<td>2,984</td>
</tr>
<tr>
<td></td>
<td>11,235</td>
<td>15,166</td>
<td>12,572</td>
<td>155,261.53</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>78</td>
</tr>
<tr>
<td>20--24</td>
<td>1,166</td>
<td>1,212</td>
<td>1,162</td>
<td>131,110.50</td>
</tr>
<tr>
<td></td>
<td>53,751</td>
<td>58,398</td>
<td>58,572</td>
<td>196,600.35</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>111</td>
</tr>
<tr>
<td>15--19</td>
<td>1,315</td>
<td>1,511</td>
<td>1,508</td>
<td>177,120.52</td>
</tr>
<tr>
<td></td>
<td>55,803</td>
<td>61,101</td>
<td>61,050</td>
<td>61,161.18</td>
</tr>
<tr>
<td>8--11</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>727</td>
<td>793</td>
<td>822</td>
<td>2,312</td>
</tr>
<tr>
<td></td>
<td>26,595</td>
<td>29,415</td>
<td>33,908</td>
<td>87,062.92</td>
</tr>
<tr>
<td></td>
<td>117</td>
<td>117</td>
<td>117</td>
<td>351</td>
</tr>
<tr>
<td>4--7</td>
<td>4,919</td>
<td>5,286</td>
<td>5,133</td>
<td>15,368</td>
</tr>
<tr>
<td></td>
<td>209,338</td>
<td>238,818</td>
<td>225,193</td>
<td>672,861.12</td>
</tr>
</tbody>
</table>
### TABLE XXXII

**SUMS OF SQUARES OF METHODS x LEVELS ANALYSIS OF VARIANCE**  
**PRETEST SCORES MATCHED**  
**CATEGORY 2: RECOGNITION AND APPLICATION OF PRINCIPLES**

<table>
<thead>
<tr>
<th></th>
<th>Sums of Squares</th>
<th>Degrees of Freedom</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>486.73</td>
<td>$(M - 1)$</td>
<td>2</td>
</tr>
<tr>
<td>Levels</td>
<td>11,097.01</td>
<td>$(L - 1)$</td>
<td>4</td>
</tr>
<tr>
<td>Cells</td>
<td>12,034.69</td>
<td>$(ML - 1)$</td>
<td>14</td>
</tr>
<tr>
<td>Methods x Levels</td>
<td>450.95</td>
<td>$(M - 1) \times (L - 1)$</td>
<td>8</td>
</tr>
<tr>
<td>Within sub-groups</td>
<td>20,430.89</td>
<td>$(N - ML)$</td>
<td>336</td>
</tr>
<tr>
<td>Total</td>
<td>32,465.58</td>
<td>$(N - 1)$</td>
<td>350</td>
</tr>
</tbody>
</table>

\[
F_{\text{methods}} = \frac{243.36}{60.81} = 4.00
\]

\[
F_{M \times L} = \frac{256.37}{60.81} = 0.9269
\]

From tables for 2 and 336 d.f., F is significant beyond 5% level.  
From tables for 8 and 336 d.f., F is non-significant.

Since a methods difference significant beyond the 5% level was indicated by the F test for methods, t-tests were made for the various level differences according to the method described in Chapter V.

The t tests indicated no differences in methods at any level. It should be noted however that at the 20—20 level a significant difference in means at the 5% level was almost indicated. A t value of 1.960 was obtained for this level. For the 336 d.f., a t value of 1.967 is significant at the 5% level.
<table>
<thead>
<tr>
<th>Initial score level</th>
<th>Day</th>
<th>Evening</th>
<th>TV</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>22,500</td>
<td>13</td>
<td>25,281</td>
<td>13</td>
</tr>
<tr>
<td>150</td>
<td>11,52</td>
<td>159</td>
<td>12,23</td>
<td>116</td>
</tr>
<tr>
<td>1,770</td>
<td>1,730.77</td>
<td>1,977</td>
<td>1,944.69</td>
<td>1,702</td>
</tr>
<tr>
<td>25-29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1,8,40C</td>
<td>20</td>
<td>55,696</td>
<td>20</td>
</tr>
<tr>
<td>250</td>
<td>1,100</td>
<td>236</td>
<td>11,80</td>
<td>195</td>
</tr>
<tr>
<td>2,542</td>
<td>2,420,00</td>
<td>2,842</td>
<td>2,784.80</td>
<td>2,015</td>
</tr>
<tr>
<td>20-21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>62,500</td>
<td>26</td>
<td>55,696</td>
<td>26</td>
</tr>
<tr>
<td>250</td>
<td>9,62</td>
<td>236</td>
<td>9,08</td>
<td>218</td>
</tr>
<tr>
<td>2,616</td>
<td>2,463.85</td>
<td>2,262</td>
<td>2,112.15</td>
<td>2,018</td>
</tr>
<tr>
<td>15-19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>93,636</td>
<td>37</td>
<td>110,224</td>
<td>37</td>
</tr>
<tr>
<td>306</td>
<td>8,27</td>
<td>332</td>
<td>8,97</td>
<td>363</td>
</tr>
<tr>
<td>2,682</td>
<td>2,530.70</td>
<td>3,238</td>
<td>2,979.03</td>
<td>2,665</td>
</tr>
<tr>
<td>8-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>17,689</td>
<td>21</td>
<td>20,736</td>
<td>21</td>
</tr>
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<td>133</td>
<td>6.33</td>
<td>144</td>
<td>6.86</td>
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<tr>
<td>929</td>
<td>812.33</td>
<td>1,081</td>
<td>992.67</td>
<td>1,038</td>
</tr>
<tr>
<td>117</td>
<td>1,121.81</td>
<td>1,225.49</td>
<td>117</td>
<td>1,060,900</td>
</tr>
<tr>
<td>1,059</td>
<td>9,585.31</td>
<td>1,107</td>
<td>10,733.92</td>
<td>1,030</td>
</tr>
</tbody>
</table>
TABLE XXXIV
SUMS OF SQUARES OF METHODS x LEVELS ANALYSIS OF VARIANCE
PRETEST SCORES MATCHED
CATEGORY 3: CRITICAL REASONING

<table>
<thead>
<tr>
<th></th>
<th>Sums of Squares</th>
<th>Degrees of Freedom</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>25.85</td>
<td>(M - 1)</td>
<td>2</td>
</tr>
<tr>
<td>Levels</td>
<td>751.16</td>
<td>(L - 1)</td>
<td>4</td>
</tr>
<tr>
<td>Cells</td>
<td>864.20</td>
<td>(ML - 1)</td>
<td>14</td>
</tr>
<tr>
<td>Methods x Levels</td>
<td>87.19</td>
<td>(M - 1) x (L - 1)</td>
<td>8</td>
</tr>
<tr>
<td>Within sub-groups</td>
<td>1,814.90</td>
<td>(N - ML)</td>
<td>336</td>
</tr>
<tr>
<td>Total</td>
<td>2,679.10</td>
<td>(N - 1)</td>
<td>350</td>
</tr>
</tbody>
</table>

\[ F_{\text{methods}} = \frac{12.92}{5.40} = 2.3931 \]
\[ F_{ML} = \frac{10.90}{5.40} = 2.0182 \]

From tables for 2 and 336 d.f., F is non-significant.
From tables for 8 and 336 d.f., F is significant at the 5% level.

Following the significant F value for methods by levels, t tests were made of the differences between means of the day, evening, and TV groups. The evening group at the 25-29 level was significant at the 1% level over TV; the t test indicated no differences between the day and TV groups at this level. The only other significant difference occurred at the 8-14 level where the TV group was favored at the 5% level over the day group. No other significant differences were indicated by the t test at any of the other levels.

The results of Tables XXIX through XXXIV indicate that the day, evening,
and TV achieved equally as well in items treating of facts, definitions, and recognition (Category 1) and those dealing with the recognition and application of principles (Category 2). In critical reasoning exercises at one of the upper levels a difference significant at the 1% level favored evening instruction over TV while at the very lowest level TV instruction was favored at the 5% level over day instruction.

In attaining the objectives pertinent to facts, definitions, and recognition it should be noted that at all levels except an initial score level of 15—19 the evening group achieved a higher mean than the TV group; these means as noted above were not however significant. The day groups also achieved a larger mean than the TV group at the upper three levels; the TV group means at the lower two levels exceeded that of the day group.

In test items dealing with the recognition and application of principles the evening group achieved a higher mean than the TV group at all levels except the lowest. Differences, however, were non-significant. The mean of the TV group exceeded the mean (again not significantly) of the day group at the 25—29, the 15—19, and 8—14 levels.

In critical reasoning exercises the evening achievement and that of the day at all levels except the lowest exceeded that of the TV group. At only one level however the evening achievement exceeded that of the TV group significantly (at the 1% level). At the lowest level the significant difference at the 5% level favored TV instruction over day.

The last page of the final examination consisted of five items which all students were asked to answer. The TV students were also asked to answer an additional ten items. The instructions preceding these exercises stated that
the exercises were not a part of the test and the answers would have no effect on the student's mark for the course. The instructions stated that the answers should express the honest conviction of the person answering the question.

The instructions preceding the exercises are as follows:

"After the number on the answer sheet which corresponds to that of each of the following statements blacken space

A  if you strongly agree with the statement
B  if you agree with the statement
C  if you neither agree nor disagree with the statement
D  if you disagree with the statement
E  if you strongly disagree with the statement"

The five items which all students were asked to answer are:

186. Inventions and discoveries in the physical sciences have created problems which science cannot solve.

187. The physical science course has taught me to reason more critically than other courses I have taken.

188. Mathematics and science should receive greater emphasis than other subjects in our high schools.

189. As a result of physical science instruction I expect to have a permanent interest in science.

190. The scientific method is the best method of obtaining knowledge concerning nature.

The answers to the items used were those of the 117 students in each group whose data were used for the methods by levels analysis matched in terms
TABLE XXXV

PERCENT OF RESPONSE TO ITEMS 186-190 OF PHYSICAL SCIENCE 101
FINAL EXAMINATION

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Group</th>
<th>Answer responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>186</td>
<td>Day</td>
<td>7.8%</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>6.4</td>
</tr>
<tr>
<td>187</td>
<td>Day</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>22.1</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>25.2</td>
</tr>
<tr>
<td>188</td>
<td>Day</td>
<td>30.2</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>33.7</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>30.3</td>
</tr>
<tr>
<td>189</td>
<td>Day</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>25.5</td>
</tr>
<tr>
<td>190</td>
<td>Day</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>50.5</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>16.8</td>
</tr>
</tbody>
</table>

of pretest scores. The percents of each type of response to items 186-190 appear in Table XXXV.

Unfortunately over fifty percent of the students in each of the day, evening, and TV groups did not believe that inventions and discoveries in the physical sciences created problems which science could not solve. The magical
role of science and the scientist as a cure-all for any problem still prevails even after one semester of instruction in college physical science.

The students in all groups overwhelmingly agreed that physical science taught them to reason more critically than other courses. Note, however, that almost 28% of the day group disagreed. It is also interesting to observe that the TV students though achieving least in critical reasoning exercises were the most emphatic in their agreement that physical science has taught them to reason more critically than other courses.

Well over one-half of all students agreed that mathematics and science should receive greater emphasis than other subjects in high schools. About one-fourth of the day and TV group neither agreed nor disagreed with this.

More TV students seemed to think that they would have a permanent interest in science as a result of physical science instruction but about 42 to 46% of the day and evening groups respectively thought that they would be permanently interested in science. About 22 to 23% of the day and evening groups stated that they would probably not be permanently interested in science at least as a result of physical science instruction.

Over 80% of all groups believed that the scientific method was the best method for obtaining knowledge concerning nature. Strangely enough 17% and 16% of the day and TV group disagreed.

The percents of each type of response to items 191 to 200 appear in Table XXXVI. These items were only answered by the TV students. The ten items are as follows:

191. Television instruction is better able to hold one's attention than regular classroom instruction.
TABLE XXXVI

PERCENT OF RESPONSES OF TV STUDENTS TO ITEMS 191-200
OF PHYSICAL SCIENCE 101 FINAL EXAMINATIONS

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Answer responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>191</td>
<td>13.5%</td>
</tr>
<tr>
<td>192</td>
<td>28.6</td>
</tr>
<tr>
<td>193</td>
<td>31.8</td>
</tr>
<tr>
<td>194</td>
<td>12.6</td>
</tr>
<tr>
<td>195</td>
<td>11.0</td>
</tr>
<tr>
<td>196</td>
<td>17.3</td>
</tr>
<tr>
<td>197</td>
<td>13.0</td>
</tr>
<tr>
<td>198</td>
<td>20.0</td>
</tr>
<tr>
<td>199</td>
<td>11.3</td>
</tr>
<tr>
<td>200</td>
<td>59.3</td>
</tr>
</tbody>
</table>

192. During television instruction one is handicapped by not being able to ask questions immediately about points which are puzzling.

193. Television instruction is better organized than regular classroom instruction.

194. Television demonstrations are not as clearly visible as those in regular classroom instruction.

195. Television instruction is more interesting than regular classroom instruction.

196. In television instruction one feels that the teacher is talking directly to him rather than to a class.
197. Television instruction makes one more anxious to learn what is taught than regular classroom instruction.

198. Television instruction would be more effective if followed immediately by a discussion period with a teacher who can supplement what was said over TV.

199. In one lesson of television instruction so much material is presented that one is not able to understand it fully.

200. A repeating of key points at the end of a television lesson is very helpful.

About one-third of the students agree that television can better hold one's attention than regular classroom instruction. One-third disagreed with this while the other third neither agreed nor disagreed.

The students overwhelmingly—about 77%—agreed that the television student is handicapped by not being able to ask questions. About two-thirds of the students were of the opinion that television instruction is better organized than regular classroom instruction; about 14% disagreed.

About half of the television students believed that television demonstrations are not as clearly visible as those in regular classroom instruction while about one-third of the students did not agree with this statement.

Thirty-one percent of the television students did not think that television instruction was as interesting as classroom instruction; 26% of the students thought television instruction was as interesting with 41% of the students not sure of their feelings.

About three-quarters of the television students had the feeling that in
television instruction the instructor was talking directly to the student rather than to a class; 11% disagreed with this.

Forty-one percent of the television students believed that television instruction makes one more anxious to learn than regular classroom instruction; 42% were not sure about this.

About 65% of the students believed that television instruction would be more effective if it were followed immediately by a discussion period with a teacher. But about 25% of the students were not sure about this.

About 31% of the students believed that a television lesson covered so much material that one was not able to understand it fully; 47% disagreed with this.

By the overwhelming majority of 94% television students believed that the repeating of key points at the end of a television lesson was very helpful; only 2% disagreed with this.
CHAPTER VII

SUMMARY AND CONCLUSIONS

This study of the Physical Science 101 offering of TV College of the Chicago City Junior College in the Fall semester of 1957-58 gives and tends to imply certain conclusions.

Considering day, evening, and TV registrants at the Wright and Wilson branches of the Chicago City Junior College, the TV registrants achieved greatest on initial Otis and initial pretest scores as well as on total achievement scores. Day students fared most poorly on all of these. All calculations of means and standard deviations were made using ungrouped data.

The fundamental assumptions of homogeneity of variance and homogeneity of regression which are fundamental to an analysis of variance and covariance are accepted.

Following an analysis of covariance an F value significant at the 1% level at the Wright Branch indicated that there were differences in the achievement of the classes taught by different instructors; these differences are not due to real differences between classroom instruction and TV instruction. One day class and one evening class achieved significantly better at the 5% level than the day classes of an experienced instructor. Two day classes and all three evening classes at the 1% level and two day classes at the 5% level achieved better than the day classes of an inexperienced instruc-
tor. It should be noted however that the evening classes of the inexperienced instructor achieved significantly better at the 1½ level over his day classes.

One is forced to conclude therefore that there are factors other than the teacher which affect the achievement of the students. This implication is quite consistent throughout the study.

Results of day totals, evening totals, and TV totals indicate that the evening totals were favored over the day totals at the 5% level. The results indicate again that there are little differences between methods but that such differences are probably due to differences in population between the day classes and evening classes.

At the Wilson Branch of the Chicago City Junior College computations again indicated that the evening students achieved significantly more at the 5% level over TV while the evening students achieved at the 1½ level over day.

The results at the Wilson Branch again seem to imply that the evening population is different from the day.

A methods by levels analysis of variance of the Wright data in which students were matched on the basis of initial Otis scores indicated that TV instruction was superior to day instruction at the 5% level for students below an Otis score of 41 (IQ 99). One is reluctant, however, to draw a valid conclusion since there were only 4 cases in each cell at this level.

The combined Wilson and Wright data when subjected to a methods by levels analysis of variance based on matched Otis scores indicated no differences except that evening instruction is favored at the 5% level over day instruction at the Otis 42-51 level (IQ 100-109).

The results seem to imply that the relative merit of the different types
of instruction is not related to the intelligence levels of the students as measured by the Otis test. One cannot conclude, therefore, that one method of instruction is better for superior students while less able students benefit more from another kind of instruction.

When pretest scores were matched a methods by levels analysis of variance of the combined Wright and Wilson data indicated that the total evening and total TV achieved significantly better at the 1% level than the total day group. This again would seem to support the inference of population differences between day, evening, and TV groups.

At the two lowest levels based on pretest scores TV instruction and evening instruction were favored at the 5% level or beyond over day instruction.

Population differences between day, evening, and TV groups exist. The average evening student is older than the average day student while the average TV student is older than either of the other groups. The average day student is under 20 years of age. Of the evening population almost 68% are between 20 to 29 years of age. The greatest part of the TV population is between 30 to 39 years of age with 29% being 40 years or over in age.

The average day student (34%) carries a full college program of five courses. About 74% of the evening students carry two or three courses. About 43% of the TV students carry two courses with 22% and 20% carrying three and four courses respectively.

About one-third of the day students do not work although another third works 10 to 20 hours per week; 20% work over 20 hours per week. Most of the evening students (87%) work over 20 hours per week. Of the TV students about 44% are homemakers and 43% work over 20 hours per week.
Thus the older evening and TV students are probably more mature and probably better motivated than the day students.

When initial pretest items were repeated in the final examination, the students in the lower half attained greater percent gains, in general, than those in the upper half of the group. In all cases the percent gains of the evening lower group were the highest.

When test items were categorized and a methods by levels analysis of variance based on matched pretest scores computed, no significant differences in achievement existed on those test items treating of facts, definitions, and recognition and those test items treating of recognition and application of principles. In those items designed to measure critical reasoning a difference significant at the 1% level favored evening instruction at one of the upper levels over TV while at the very lowest level TV instruction was favored at the 5% level over day instruction.

The students in all groups overwhelmingly agreed that physical science taught them to reason more critically than other courses. About 28% of the day group, however, disagreed. The TV students who achieved least in critical reasoning exercises were the most emphatic in their agreement that physical science had taught them to reason more critically than other courses.

About one-half of all students agreed that mathematics and science should receive greater emphasis than other subjects in high schools. About one-fourth of the day and TV groups neither agreed nor disagreed with this.

About 65% of the TV students, 42% of the day group, and 46% of the evening group believed that they would have a permanent interest in science as a result of physical science instruction. About 22 to 23% of the day and evening
groups stated that they probably would not be permanently interested in science at least as a result of physical science instruction.

Though 17% of the day and 16% of the TV group disagreed that the scientific method was the best method for obtaining knowledge, over 30% of all groups believed that the scientific method for obtaining knowledge was superior.

Amongst the TV students one-third thought that television instruction can better hold one's attention than regular classroom instruction, but another third disagreed with this while the other third was undecided.

TV students overwhelmingly agreed that the television student is handicapped by not being able to ask questions. They also believed that TV instruction is better organized than regular classroom instruction.

About half of the TV students believed that television demonstrations are not as clearly visible as those in regular classroom instruction; one-third disagreed with this.

About 41% of the TV students were not sure about their feelings with regard to TV instruction. Thirty-one percent of the TV students did not think television instruction as interesting as classroom instruction while 26% thought it as interesting.

The TV students overwhelmingly believed that in television instruction the instructor was talking directly to the student rather than to a class. Though 41% of the TV students believed that TV instruction makes one more anxious to learn than regular classroom instruction, 42% were not sure about this.

Two-thirds of the TV students believed that television instruction would
be more effective if TV instruction were followed immediately by a discussion period with a teacher.

About one-half of the TV group believed that adequate material was covered in a television lesson, but about one-third believed that so much material was covered that one was not able to understand it fully.

The TV students overwhelmingly believed that the repetition of key points at the end of a television lesson was very helpful.

In conclusion the author would like to make two points.

Though no positive conclusions regarding the relative efficiency of television and regular classroom instruction are warranted, it is quite clear that television students attain higher raw achievement scores than regularly enrolled students. If such scores are criteria for achievement in the subject matter and such scores are the basis for granting credit, there can be no question as to the validity of television or regular classroom instruction as a basis for granting college credits.

The statement is often made that the higher levels of achievement of the TV students may be attributed to the higher initial capacity of the groups enrolled for TV instruction and to their greater maturity and motivation. The present study indicated higher achievement for evening students if corrections are made for the initial knowledge of subject matter and mental ability as measured by an intelligence test. Therefore if regularly instructed evening students are to receive college credit based on their achievement scores then TV students who are graded on similar norms of attainment also merit college credit.

In this and many other studies in which comparison is made between groups
taught by television or by regular instruction the differences in achievement reported are frequently "not statistically significant." The logic of statistical inference does not permit one to conclude that the two methods are equally effective or that "TV instruction is as good as regular instruction."

While the protagonist for TV instruction cannot make the claim just stated, it should also be emphasized that the critic of TV instruction cannot conclude from the same data that TV instruction is less effective than regular instruction in the attainment of the objectives measured. The fact that this is the case and the fact that, regardless of the factors involved, TV students achieve marks worthy of college credit does support the general conclusion that TV instruction of the kind characterized by the Chicago City Junior College program is definitely worthwhile as a means of providing college instruction to hundreds of persons who would not otherwise find it possible to obtain college instruction.
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### PHYSICAL SCIENCE 101 STUDENT WRIGHT DATA

#### APPENDIX I

**TABLE I**

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### APPENDIX I

#### TABLE II

**PHYSICAL SCIENCE 101 SUMMARY SHEET**

**WILSON DATA**

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\(a\) refers to one section taught by teacher B; \(B_2\) to second section taught by same teacher.
APPENDIX II

Physical Science Pretest

Midterm Examination 1
  Geology and Scientific Method

Midterm Examination 2
  Meteorology
  Astronomy

Semester Examination
DIRECTIONS: Print your name (last name first), the title of the examination, the name of your college, and the date on the designated blanks on the answer sheet. If you are enrolling in Physical Science 101 as a television student, write TV after your name.

If you do not understand the directions preceding the exercises, ask the proctor for an explanation. When marking your answers on the answer sheet, you must use a pencil filled with the special scoring machine lead. Make your marks thus:

```
A B C D E
•••••••••••
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•••••••••••
100. ••••••••
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1. Solid black marks are made by going over each mark two or three times and by pressing firmly on your pencil.

2. If you change your mind, erase your first mark completely.

3. Make no unnecessary marks in or around the dotted lines. Do not rest your pencil on a lettered space while deciding which space to mark.

4. Keep your answer sheet on a hard surface while marking your answers.

5. Make your marks as long as the pair of dotted lines.

6. Make one mark and only one mark after each answer sheet number from 4 to 56.

You will have 30 minutes for this test. Your score will not affect your final course mark. While the exercises pertain to things you will be taught in Physical Science 101, in order to evaluate the effectiveness of the course we wish to obtain an estimate of how much students know of these things before taking the course. Hence, we should like to have you answer each exercise as best you can according to your present knowledge.

Items 1-6 are not a part of the test, but your answers will help us in our evaluation research.
After the number on the answer sheet corresponding to each of the following six items, blacken as many answer spaces as are necessary to indicate your previous training in science or mathematics, but blacken only one answer space each for items 4, 5 and 6.

1. I have had
   A. high school general science.
   B. high school biology, zoology, or botany.
   C. high school chemistry.
   D. high school physics.
   E. none of the above courses.

2. I have had
   A. college biology, zoology, or botany.
   B. college chemistry.
   C. college physics.
   D. none of the above courses.

3. I have had
   A. elementary algebra.
   B. elementary plane geometry.
   C. advanced algebra.
   D. solid geometry and/or trigonometry.
   E. none of the above courses.

4. I am
   A. under 20 years of age.
   B. 20 to 24 years of age.
   C. 25 to 29 years of age.
   D. 30 to 39 years of age.
   E. 40 or over 40 years of age.

5. I am enrolled in
   A. no other course.
   B. one other course.
   C. two other courses.
   D. three other courses.
   E. four other courses, or more.

6. In addition to being enrolled as a regular or TV student, I am
   A. a housewife and not employed.
   B. not working or working less than 5 hours per week.
   C. working 5 to 10 hours per week.
   D. working 10 to 20 hours per week.
   E. working over 20 hours per week.

After the number on the answer sheet which corresponds to that of each of the following exercises, blacken one lettered space to indicate the correct answer.

7. Which of the following is most destructive to a theory?
   A. The opposition of a great scientist.
   B. A new and conflicting theory.
   C. A carefully formulated subjective opinion.
   D. New facts contradicting the theory.
   E. A new hypothesis in opposition to the theory.

8. Which of the following best expresses the purpose of experimentation?
   A. The application of a general law to a new situation.
   B. The obtaining of new evidence to test an hypothesis.
   C. The obtaining of evidence which will support a theory.
   D. The obtaining of evidence which will disprove a theory.
   E. The elimination of subjective thinking from the behavior of a scientist.

9. Numerous observations and experiments have shown that "all chemical compounds have a definite composition." The quoted words best exemplify
   A. a scientific law or generalization.
   B. an hypothesis.
   C. a result of deductive reasoning.
   D. an assumption.
   E. reasoning from the abstract to the concrete.
10. When one evolves a new explanation of why a certain cause produces a certain effect with the idea of testing the explanation by means of data, it is most appropriate to call the explanation 
A. a deduction. 
B. a scientific law. 
C. an example of inductive reasoning. 
D. a general theory. 
E. an hypothesis. 

11. A scientist thinks that he understands why a certain cause produces a certain effect, but he refuses more than tentatively to accept his explanation until he has collected adequate data. It is evident from the above alone that this scientist possesses 
A. scientific knowledge. 
B. common sense. 
C. scientific attitude. 
D. the correct solution to his problem. 
E. a willingness to rationalize. 

12. A ship floats because 
A. it displaces a weight of water equal to its own weight. 
B. the air in the hold is buoyant. 
C. the surface tension of the water prevents it from sinking. 
D. water is nearly incompressible. 
E. its shape corresponds to that of the flow-lines of the water. 

13. Bullets from a .45 cal. pistol have a velocity of about 500 miles per hour. Such a bullet is fired due West from the tail of a jet plane traveling due East at 800 miles per hour. Immediately after the pistol is fired, the velocity and direction of the bullet relative to the earth’s surface are 
A. 500 miles per hour, West. 
B. 1300 miles per hour, East. 
C. 300 miles per hour, West. 
D. 300 miles per hour, East. 
E. 600 miles per hour, East, since the bullet never leaves the pistol. 

14. Clouds form when 
A. there is an increase in the temperature of the air. 
B. the center of an air mass arrives at a given area. 
C. wind velocities reach a certain critical value. 
D. moist air rises to higher elevations. 
E. the air has absorbed a certain amount of heat from the sun. 

15. If a baseball is thrown straight upward, at the very top of its flight 
A. its potential energy is equal to one-half of its kinetic energy. 
B. it possesses no energy. 
C. its potential energy will be at a minimum while its kinetic energy will be maximum. 
D. it will possess no potential energy and one-half of its kinetic energy. 
E. it will possess no kinetic energy and its maximum potential energy. 

16. If the diameter of the earth were twice its present value while the mass remained the same, the weight of an object on the earth’s surface would be 
A. one-fourth its present value. 
B. one-half its present value. 
C. the same as its present value. 
D. twice its present value. 
E. four times its present value. 

17. Future travelers, wearing space suits, may sometimes walk about on the outside of a space ship while the ship is moving with uniform velocity through space between the earth and Mars. They will be subject to all of the following hazards except 
A. being struck by meteorites. 
B. becoming dangerously chilled. 
C. being blown off the ship. 
D. being exposed to cosmic rays. 
E. suffering from lack of oxygen.
18. In a Chicago quarry the walls are thick horizontal layers of a pale gray rock which contains many tiny shells of marine animals. This rock dissolves slowly in water containing carbon dioxide. It is probably
A. granite.
B. limestone.
C. basalt.
D. sandstone.
E. shale.

19. In California, roads and stream beds are broken when they cross a line several hundreds of miles long. They are displaced some ten feet to one side when they cross the line. This is due to
A. volcanic action.
B. landslides.
C. erosion.
D. faulting.
E. slumping.

20. Which one of the following would offer the best basis for concluding that a certain layer of shale in New York was deposited at the same time as one in California?
A. They are the same distance below the surface.
B. They contain similar fossil remains.
C. They have the same chemical composition.
D. They are both sedimentary rocks.
E. Each one is between two sandstone layers.

21. Which of the following characteristics would enable you to recognize the deposits of a continental ice sheet?
A. Sediments unsorted with respect to size.
B. Sediments containing many different types of rock, spread over a large area.
C. Sediments having an irregular, hilly, undrained topography.
D. All of the above.
E. None of the above.

22. The existence of a flood-plain along a stream indicates that
A. the stream must be more than 15 million years old.
B. the stream has cut down to very hard rock.
C. the stream's rate of downcutting has decreased to almost, but not quite, zero.
D. the rate of weathering has increased markedly, and rather rapidly.
E. the stream is very old, and will shortly die for lack of water.

23. Caverns and underground tunnels occur in limestone strata when ground water
A. contains dissolved minerals.
B. has been heated by contact with hot masses of rock.
C. emerges to form a spring.
D. attacks a recent igneous intrusion.
E. contains dissolved carbon dioxide.

24. An unconformity in rock strata as shown in the diagram indicates
A. deposition of large quantities of unsorted material.
B. that a transitory feature definitely existed in the area at one time.
C. a long period of erosion followed by submergence and sedimentation.
D. that igneous rock is usually beneath the sedimentary layers.
E. that mountains have been produced at one time due to differential erosion.
25. In a series of sedimentary rock layers
   A. a layer of limestone always is beneath the layer of sandstone.
   B. the most recent layer of the series is sandstone.
   C. the most recent layer is the top layer.
   D. the layer at the bottom of the series is the most recent layer.
   E. nothing can be said about the time sequence of the layers in the series.

26. If an igneous intrusion has passed through a layer of sedimentary rock in a series of such layers
   A. the intrusion is probably younger than the layer through which it passed.
   B. the intrusion is probably older than the layer through which it passed.
   C. a geyser is likely to be formed.
   D. an unconformity will probably result.
   E. no conclusion can be drawn as to the time sequence of the layer of sedimentary rock through which the intrusion passed and the intrusion.

After the number on the answer sheet which corresponds to that of each of the following paired items, blacken one lettered space to indicate that
A. the item in Column I is greater than the item in Column II
B. the item in Column II is greater than the item in Column I
C. both items are equal, or it cannot be said that one is greater than the other

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. Extent to which dry weather is characteristic of the equatorial zone.</td>
<td>..... Extent to which rainy weather is characteristic of the equatorial zone.</td>
</tr>
<tr>
<td>28. Tendency of winds in the zone between 30° N. and 60° N. to blow from the west.</td>
<td>..... Tendency of winds in the zone between 30° S. and 60° S. to blow from the west.</td>
</tr>
<tr>
<td>29. The height of the mercury in a barometer at the foot of a mountain.</td>
<td>..... The height of the mercury in the barometer when carried to the top of the mountain.</td>
</tr>
<tr>
<td>30. Extent to which during summers in the temperate zones, high pressures and low temperatures characterize large land areas.</td>
<td>..... Extent to which during summers in the temperate zones, low pressures and high temperatures characterize large land areas.</td>
</tr>
</tbody>
</table>
After each item number on the answer sheet, blacken the one lettered space which designates the correct answer.

31. Moving air seems cooler to a person than still air, because
   A. moving the air gives it a lower temperature.
   B. moisture from the body is evaporated more rapidly.
   C. moving air on the face reduces evaporation.
   D. moving air has the greater specific heat.
   E. still air has the greater specific heat.

32. St. Louis and Chicago have about the same average minimum low temperatures during the winter even though Chicago is about 300 miles farther north. One explanation is that
   A. St. Louis is closer to sea-level.
   B. 300 miles is insufficient to note changes in average minimum low temperatures.
   C. Lake Michigan loses heat slowly.
   D. river towns have mild winters.

33. If the temperature of a certain time of day is 85°F and the relative humidity is 94 percent,
   A. relative humidity will have to decrease before rain will fall.
   B. it is sure to be raining.
   C. any increase in temperature will be accompanied by an increase in relative humidity.
   D. an increase in temperature of 15°F will cause rain.
   E. it will rain if the temperature decreases sufficiently.

34. What is meant by saying that the relative humidity on a certain day is 80%?
   A. That water vapor in the air constitutes 80% of the air.
   B. That the air contains 80 parts of water to 100 parts of dry air.
   C. That the air contains 80% of the water vapor it is capable of holding.
   D. That the air contains the same amount of water that it would contain at 80°F Fahrenheit.

35. Hundreds of years ago natural levees in the lower Mississippi Valley were about 3 ft. high. Man has built these levees to greater heights in an attempt to retain seasonal flood waters. One must conclude that more water is being diverted into the river channel because man has
   A. cut down huge forests.
   B. plowed under pasture lands adjacent to the river valleys.
   C. diverted more water into the river valleys.
   D. filled in swamp lands adjacent to the river valley.
   E. done two or more of the above things.
36. At an altitude of 24,000 feet the height of a mercury column in a barometer is 11.80 inches, while at sea level it is 29.92 inches. One can infer from these data alone that
A. there is insufficient oxygen at 24,000 feet to support life.
B. the air contains much less than 20 per cent oxygen by volume.
C. there is almost no carbon dioxide in the air.
D. the weight of the air above 24,000 feet is about 40 percent of the weight of the air above sea-level.
E. water will not boil at this altitude.

37. The deposition of sediment by a stream increases as the
A. velocity increases.
B. velocity decreases.
C. particle size decreases.
D. volume of water increases.
E. slope of the bed increases.

38. Which of the following is the best proof that the earth rotates on its axis, in other words, the observation cannot plausibly be explained in some other way?
A. The sun rises in the east and sets in the west every day.
B. Star trails circle about the North Star if the camera is pointed at the North Star.
C. Stars are on the meridian a little later each night.
D. The plane of swing of a long pendulum changes as the hours go by in all places on earth except at the equator.
E. Nearby stars shift in their direction from the earth more than do the distant stars.

39. An observer in Minnesota notes that the North Star is 50° above the horizon. The observer's latitude is
A. 50° N.
B. 40° N.
C. 0° N.
D. indeterminate.

40. If an individual were able to get to the moon, he would find certain conditions which would be detrimental to life. In the following, all but one are experiences the observer might encounter. Select the one possibility that you know is in error.
A. There would be no oxygen to support life.
B. There would be extreme temperature changes from day to night.
C. Only one side of the earth would ever be visible from the moon.
D. There would be a small gravitational effect as compared to the earth.
E. The earth would be visible as a large reflector of sunlight.
41. Suppose that men in a space ship are able to land on the moon when it is a new moon and on the side toward the earth. Which of the following would be true?
A. The earth would appear like a very large full moon.
B. The moon's surface around their landing place would be totally dark.
C. The earth would appear faintly illuminated by moonlight.
D. The earth would look like a quarter moon.
E. The moon's surface around their landing place would be in bright sunlight.

42. The sun shines on the North Pole area day and night for almost six months every year yet it is extremely cold there during this time. The reason for this is that
A. there are large areas of water which are difficult to heat up.
B. there are large land areas which are difficult to heat up.
C. the other six months there is no sun at all.
D. at no time is the altitude of the sun very high.
E. the rotational speed of the pole area is much smaller than that of the equatorial area.

43. It is commonly said that people in general in ancient times believed that the earth is flat. If ancient astronomers had also believed this, they would have been unable to measure the
A. altitude of the sun.
B. time of the solstices.
C. size of the earth.
D. time of day.
E. length of the year.

44. Observation of a full moon as it enters the earth's shadow during an eclipse of the moon is useful in
A. studying the corona of the sun.
B. providing evidence that the earth is a sphere.
C. discovering whether or not the moon has any atmosphere.
D. determining the distance of the moon from the earth.

45. If one knows only that the sun and moon have very nearly the same angular or apparent size when observed in the sky, it can be concluded that
A. the sun is much larger than the moon.
B. the sun is much further from the earth than the moon.
C. the sun is both much larger and much further away than the moon.
D. more information is needed to prove that the sun is much larger and further away than the moon.
After the number on the answer sheet corresponding to that preceding each of the following paired items, blacken space

A if the two things referred to tend to increase together, or to decrease together
B if one of the two things tends to increase while the other tends to decrease
C if neither of the above relationships exists

(Assume that other factors remain the same.)

46. The potential energy of a falling body.
   The kinetic energy of the same body while falling.

47. The rapidity of motion of the molecules of a gas.
   The temperature of the gas.

48. The weight of an object.
   The rate at which the object falls when dropped in a vacuum.

49. Distance through which a body has fallen in a vacuum.
   Velocity at which the same body is falling.
READ THE FOLLOWING SELECTION CAREFULLY. It is taken from a book called "Life on the Mississippi."

(1) "In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. (2) Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Blacken one lettered space to designate the best answer.

50. Statement 1 about the shortening of the Lower Mississippi is
   A. nothing more than a guess.
   B. presumably true because rivers usually become shorter as they grow older.
   C. presumably true because the necessary measurements could have been made in the period indicated.
   D. presumably false because everyone knows that the Mississippi is lengthening instead of shortening.
   E. presumably false because the necessary measurements could not have been made by a single individual.

51. The length of the Lower Mississippi a million years ago as given in statement 2 is
   A. a fact.
   B. the result of reasoning on the basis of extension of data.
   C. a hypothesis to be tested.
   D. the result of testing.
   E. evidence upholding or disproving a hypothesis.

52. Statement 2 was obtained by
   A. making a generalization on the basis of facts.
   B. inductive reasoning from a previously known generalization.
   C. simple calculation without assumptions.
   D. calculation assuming a constant rate of change.
   E. inference from geological studies.

53. The validity of statement 2 is
   A. disproved by the fact that the action described is obviously impossible.
   B. impossible to prove or disprove, because one cannot live the length of time indicated.
   C. impossible to prove or disprove, because no instruments are available to measure such distances or periods of time.
   D. impossible to check, because no geological data are available covering the period of time mentioned.
   E. impossible to check experimentally by direct measurements.
54. Statement 2 is probably
A. true, because by the process of extrapolation statement 2 follows from statement 1.
B. true, because the statement is obvious.
C. false, because no one ever saw the Lower Mississippi a million years ago.
D. false, because other geological data are ignored.
E. difficult to prove either true or false.

55. The 242-mile shortening of the Lower Mississippi referred to was probably caused by
A. erosion of that portion sticking "out over the Gulf of Mexico like a fishing rod."
B. widening of the Gulf of Mexico through sinking of its shores.
C. an increase in the width of the Mississippi.
D. a decrease in the number of curves and a straightening of the river channel.
E. a decrease in the amount of water carried by the river.

56. A science teacher might use this article to
A. show that one should not make wholesale conjectures based on incomplete data.
B. show that he understands the geology of the Lower Mississippi.
C. show that science is fascinating.
D. show the reaction of a calm person, who is neither blind nor idiotic.
E. present a history of the Lower Mississippi.
DIRECTIONS: Print your name, the title of the examination (PHYSICAL SCIENCE 101, FORM A), the branch of your college, the date, your instructor's name, and your section in the appropriate blanks in the margin of the answer sheet.

Specific directions are stated for each part of the examination, and it is essential that you follow them precisely. If you do not understand the specific directions, ask the proctor for an explanation.

When marking your answers on the answer sheet, you must use a pencil filled with the special scoring machine lead. Make your marks thus:

```
A B C D E
  '' '' '' ''
  '' '' '' ''
  100. '' '' '' ''
  '' '' '' ''
  '' '' '' ''
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1. Solid black marks are made by going over each mark two or three times and by pressing firmly on your pencil.

2. If you change your mind, erase your first mark completely.

3. Make no unnecessary marks in or around the dotted lines. Do not rest your pencil on a lettered space while deciding which space to mark.

4. Keep your answer sheet on a hard surface while marking your answers.

5. Make your marks as long as the pair of dotted lines.

6. Make one mark and only one mark after each answer sheet number. Your score will be reduced by an amount equal to the number of extra marks on your answer sheet.

7. You are expected to answer every item. If you are not sure of the answer to an item, put down the answer that seems most likely to you.

Fifty minutes will be allowed for this examination. When you have finished, turn in the examination booklet and the answer sheet.
1. Which of the following is the most readily observable evidence of glaciation in the Chicago region?  
   (A. Cirques; B. eskers; C. U-shaped valleys; D. moraines; E. striae.)

2. Ground water containing dissolved silicon dioxide fills a small cavity in a rock. Which of the following is most likely to form in the cavity?  
   A (A. concretion; B. geode; C. pot hole; D. stalactite; E. cirque).

3. The fact that remains of marine animals have been found far inland is evidence of (A. volcanism; B. erosion; C. gradation; D. diastrophism; E. exfoliation).

4. It is possible to tell whether a rock has been formed close to the surface or at great depths by its (A. color; B. crystal size; C. composition; D. acidity).

5. A sedimentary rock whose sediments consist of clay or mud is known as (A. chert; B. limestone; C. shale; D. conglomerate; E. sandstone).

6. Which one of the following rocks is formed mainly by the cementing together of gravel and pebbles?  
   (A. Conglomerate; B. basalt; C. gneiss; D. anthracite; E. marble.)

7. Which one of the following features is due primarily to folding of rock strata?  
   (A. A sill; B. a fluvial plain; C. a batholith; D. a laccolith; E. an anticline.)

8. In a Chicago quarry the walls are thick horizontal layers of a pale grey rock which contains many tiny shells of marine animals. It dissolves slowly in water containing carbon dioxide. It is probably (A. sandstone; B. granite; C. basalt; D. limestone; E. shale).

9. Which one of the following would offer the best basis for concluding that a certain layer of shale in New York was deposited at the same time as one in California?  
   A. Each one is between two sandstone layers.  
   B. They are the same distance below the surface.  
   C. They have the same chemical composition.  
   D. They are both sedimentary rocks.  
   E. They contain similar index fossils.

10. A deep well has less chance of going dry than a shallow one, because of  
    A. deep underground springs and streams which can feed deep wells.  
    B. deep and porous layers of sandstone between layers of tight shale.  
    C. less likelihood that the water table will fluctuate below the bottom of a deep well.  
    D. less downward soaking in a deep well.  
    E. less evaporation from a deep well.

11. The existence of a flood-plain along a stream  
    A. indicates that the stream must be more than 15 million years old.  
    B. is made only when the stream has cut down to very hard rock.  
    C. indicates that the stream's rate of downcutting has decreased to almost, but not quite, zero.  
    D. shows that the rate of weathering has increased markedly, and rather rapidly.  
    E. suggests that the stream is very old, and will shortly die for lack of water.

12. A typical youthful river valley shows which of the following characteristics?  
    A. Few short tributaries.  
    B. Carries fairly large rocks.  
    C. Flood plain begins to form.  
    D. All three of the above.  
    E. Only the first two characteristics and not the third.

13. The deposition of a stream increases as the  
    A. velocity decreases.  
    B. velocity increases.  
    C. particle size decreases.  
    D. volume of water increases.  
    E. slope of the bed increases.
14. Three and no more than three of the following items belong to a common category: cirques, sand bars, meanders, ground moraines, sink holes, hanging valleys. The common category is concerned with landscape features that are due mainly to gradation by
A. ground water.
B. old age streams.
C. mature streams.
D. glaciers.
E. winds.

15. Which of the following kinds of rock can be converted to magma by volcanism?
A. Sedimentary only.
B. Igneous only.
C. Metamorphic only.
D. Only igneous and metamorphic.
E. Sedimentary, metamorphic and igneous.

16. The most logical explanation of the formation of ox-bow lakes is
A. the persistence of lagoons upon the emergence of shore lines.
B. geologic changes in climate causing a formerly rainy region to become relatively dry.
C. underground springs oozing towards the surface.
D. the straightening out (cutting through) of an old meandering river, thereby leaving remnants of old meanders.
E. the melting of glaciers.

17. Petrification of wood involves
A. elimination of the woody substances and their replacement with minerals.
B. a slow baking process whereby the clay in the spaces of the wood is hardened.
C. a compacting of the wood due to great pressures: followed by cementation by silica.
D. deposition of minerals in the spaces between the wood fibers.
E. chemical oxidation of soft wood fibers to hard mineral-like substances.

18. Which of the following would cause geologists to reject a given fossil as an index fossil?
A. It is easy to identify.
B. It is found in layer after layer of sedimentary rock separated by unconformities.
C. It is found in the rocks of more than one continent.
D. It contains none of the material composing the original organism, all of which has been replaced by calcium carbonate or silicon dioxide.

19. An essential condition for the successful drilling of an artesian well is the existence of a
A. meandering stream.
B. pervious rock layer in the form of an anticline.
C. spring at the lowest level in a valley.
D. sloping layer of pervious rock between layers of impervious rock.

20. What is the difference between a moraine and an esker?
A. The first is formed by glacial action while the second is not.
B. The first is formed at the end of a glacier, the second at the head of a glacial valley.
C. The first is formed along the sides or ends of glaciers while the second is formed beneath a glacier.
D. The second is the outwash plains which protrude from the first.
E. The first contains rocks while the second does not.

21. What is the difference between cirques and striae?
A. The second but not the first may be taken as evidence of the earlier presence of a glacier.
B. The first are examples of glacio-fluvial deposits, while the second are streaks in rocks due to varying crystalline structure.
C. A cirque is a crevasse while a stria is a crack.
D. Cirques are hanging valleys while striae are types of eskers.
E. The first are amphitheater-like depressions cut by glacial ice at the heads of valleys while the second are glacial scratches on rocks.

22. What is a difference between an old and winding stream and one that has been rejuvenated?
A. The first is characterized by meanders while the second is not.
B. The second may have entrenched meanders.
C. The first has tributaries while the second does not.
D. The first stream flows faster than the second.
E. The second has none of the characteristics of a youthful stream.
For each of the following items, blacken one lettered space to designate that the item:

A intrusion
B uniformitarianism
C organic correlation
D superposition
E unconformity

23. The processes of gradation, volcanism, and diastrophism, with which we are familiar
been in operation throughout geologic history in essentially the same form; and fr
results of these processes we can interpret the history of the earth.

24. Certain kinds of fossil plants and animals are characteristic of a formation of a
age. Widely separated formations containing the same kinds of fossils are therefore
geologic age.

25. A lost time interval is indicated when it is evident that a series of rocks was de
uplifted, eroded, and then covered by the deposition of a new series.

26. Intrusive rock is younger than that which is intruded.

27. In a series of rock formations, the younger rocks are at the top and the older one
bottom unless the former have been transposed by some violent disturbance.

Several substances are listed below and underlined. After the answer sheet number of th
below the name of the substance, blacken one lettered space to designate the class of wh
the given substance belongs. After the answer sheet number of the second item, b
lettered space to designate the process by which the substance was formed.

Granite

28. class: ___
29. process: ___

Shale

30. class: ___
31. process: ___

Gneiss

32. class: ___
33. process: ___

For each of the following items, blacken one lettered space to designate that the item:

A depositional action of ground water
B erosional action of ground water
C depositional action of running water
D erosional action of running water
E some agent other than ground water or running water

37. Limestone cave. 42. Stalagmite.
38. Delta. 43. Hanging valley.
The following exercises pertain to the geological diagram. After each exercise number on the answer sheet, blacken one lettered space to designate the correct answer.

44. In which of the following answers does the first symbol refer to igneous rock having the largest crystals and the second symbol refer to rock having smallest crystals? (A. h and i; B. i and d; C. i and h; D. d and h; E. g and h.)

45. The fault aa is probably (A. older than g; B. younger than g; C. of uncertain age as compared to g).

46. We know that this is true because (A. g is composed of igneous rock; B. aa does not penetrate i; C. aa does not penetrate the strata labeled I; D. not enough data are given).

47. The forces which formed fault aa (A. were compressional; B. were tensional; C. cannot be determined).

48. We know that this is true because (A. the slope of the fault is steep; B. the hanging wall has apparently moved down relative to the foot wall; C. the hanging wall has apparently moved up relative to the foot wall; D. not enough data are given).

49. Which one of the following occurred when kk was formed? (A. An unconformity; B. an anticline; C. a hurricane; D. a geosyncline; E. an earthquake.)

50. The fault kk is probably (A. younger than g; B. older than g; C. of uncertain age as compared to g).

51. We conclude this because (A. g is composed of igneous rock which penetrated strata I; B. g is higher than I; C. there is a break in dd; D. not enough data are given).

52. The rock strata surrounding cave e are (A. sandstone; B. conglomerate; C. limestone; D. shale; E. granite).

53. Which of the following constituents of the earth's atmosphere was a factor in the formation of e? (A. Nitrogen; B. oxygen; C. argon; D. helium; E. carbon dioxide.)
60. When one evolves a new explanation of why a certain cause produces a certain effect, it is most appropriate to call the new explanation, prior to its testing by means of data, 
A. a deduction. 
B. a scientific law. 
C. an hypothesis. 
D. a general theory. 
E. an example of inductive reasoning. 

61. The first step in the general pattern of scientific thinking is the 
A. setting up of an hypothesis. 
B. testing of an hypothesis. 
C. application of a general principle. 
D. recognition and definition of a problem. 
E. collecting of observational or experimental data. 

62. Numerous observations by a geologist cause him to come to the conclusion that "sediments deposited by water are sorted according to size." The quoted words best exemplify 
A. a result of deductive reasoning. 
B. an hypothesis. 
C. a scientific law or generalization. 
D. an assumption. 
E. reasoning from the abstract to the concrete. 

63. The process by which the geologist arrived at the conclusion just quoted from his numerous observations best exemplifies 
A. inductive reasoning. 
B. speculative thinking. 
C. the use of a working hypothesis. 
D. deductive reasoning. 
E. an application of a general principle. 

64. Existence of a large flood plain on either side of a stream indicates 
A. an old stream in a broad valley. 
B. a stream in the age range of about 15,000 to 20,000 years old. 
C. hard bedrock beneath the stream but softer beds on the side. 
D. that at one time a glacier existed in the valley. 
E. that weathering has increased markedly and rather rapidly. 

65. In certain regions of the world it is possible to observe thick deposits of fine material from thirty to one hundred feet thick which are not characterized by horizontal stratification. A formation of this kind is the work of 
A. a glacier. 
B. running water. 
C. ground water. 
D. rain. 
E. the wind. 

66. The material in the formation referred to in the above exercise is known as 
A. talus. 
B. loess. 
C. till. 
D. alluvium. 
E. breccia. 

67. Geologists know that seas once covered the Chicago region because 
A. the land surface is flat. 
B. sand deposits are found in parts of Illinois. 
C. of the absence of large quantities of igneous rocks. 
D. of the presence of marine fossils in the rocks. 
E. of the moist climate.
68. A stream characterized by entrenched meanders most resembles a youthful stream in its
A. lateral erosion.
B. straight direction of flow.
C. numerous tributaries.
D. broad flood plain.
E. steep banks.

69. Our present day Lake Michigan
A. has been this same way since the beginning of the Cenozoic era.
B. was originated as an arm of an ancient Atlantic Ocean.
C. is essentially the product of glacial erosion during the Ice Age.
D. resulted from erosion occurring in the Paleozoic Era.
E. formed as a result of sinking of this area by diastrophism.

70. A river is characterized by well-developed tributaries and by lateral erosion. One would also
expect to find this river characterized by
A. V-shaped walls.
B. falls and rapids.
C. diminished gradient and narrow divides.
D. maximum breadth of divides.
E. an increased gradient.

71. The northeastern coast of the United States has many bays and promontories such as Cape Cod. The chief factor in producing this condition has been
A. recent gradual elevation of the land.
B. the action of lateral shore currents.
C. the erosional effect of wave action.
D. recent gradual submergence of the land.
E. a wind erosion and water erosion.

72. Mountains can be formed
A. only by the up-folding of the earth’s crust into an anticline.
B. only by faulting and the down-slipping of blocks so that sections are left standing.
C. only by the build up of volcanic materials.
D. only by the erosion of softer material thereby leaving sections standing.
E. by all of the above processes.

73. In order for a geyser to erupt, the rocks surrounding the fissures which supply the steam
must have a temperature higher than 212° F. This is necessary because
A. the pressure of the surrounding rocks must be overcome.
B. water boils about 212° F. at high elevations.
C. the pressure of water in the geyser tube raises the boiling point of the water in contact
with the hot rocks above 212° F.
D. ground water contains dissolved salts, and, hence boils at a much lower temperature.
E. one eruption raises the pressure which must be reduced before another eruption can take
place.

74. The low ridge in the northwest part of Chicago is thought to be a moraine. If there was a
deep excavation, what could one look for to substantiate this conclusion?
A. Unsorted rocks found in the excavation.
B. Rocks having a different composition than those in the immediate vicinity.
C. Rocks with parallel scratches.
D. Surface material not derived from bed rock.
E. All of the above.

75. One of the reasons that fewer large rock structures are found in the tropics than in other
climates is
A. unconformities in the rock structure prevent any large scale uplifting.
B. the process of exfoliation is more pronounced in areas of higher temperatures.
C. chemical disintegration is accelerated by higher temperatures and ample moisture.
D. the "sandblast" effect of the wind is more effective in the humid tropics.
E. the equator region is free from faulting and folding.
Below are some statements which are true. Following each statement are a number of items which may be true or may be false. For each of the items, blacken one lettered space to designate that the item

A is a definition
B is an hypothesis
C presents evidence which supports the statement
D presents evidence which contradicts the statement
E presents evidence which has no bearing on the statement

STATEMENT: A large glacier covered Chicagoland during recent geologic time.

76. "Dump" deposits -- low hills and ridges and irregular undrained hollows -- similar to those around Chicago are found in presently glaciated regions of the Alps and Rockies.

77. A terminal moraine is the deposit left at the end of a glacier, when the rate of advance equals the rate of melting for a considerable time.

78. The bedrock upon which Chicago stands is limestone.

79. Perhaps the glacial age was caused by volcanic dust in the atmosphere, which cut off the sun's heat and light from the earth.

80. The low hills and depressions around the Chicago area exhibit a composition of unsorted material.

STATEMENT: The glacier which once covered Chicagoland moved from Northeast to Southwest.

81. The many moraine ridges in Chicagoland curve around the shore of Lake Michigan to the south and west.

82. Great sand dunes are found today on the southeast and east shores of Lake Michigan.

83. Found in the glacial debris covering Chicago are fragments of rock native to Minnesota.

84. The glacier which covered Chicagoland may have originated in Newfoundland.

85. A valley glacier is a river of ice.

When you have finished the test go over each of your marks again with the special pencil to make each mark solid, black and glossy. Erase all superfluous marks on the answer sheet no matter how tiny.

YOUR SCORE WILL BE REDUCED BY AN AMOUNT EQUAL TO THE NUMBER OF EXTRA MARKS ON YOUR ANSWER SHEET.
DIRECTIONS: Print your name, the title of the examination (PHYSICAL SCIENCE 101, FORM A), the branch of your college, the date, your instructor’s name, and your section in the appropriate blanks in the margin of the answer sheet.

Specific directions are stated for each part of the examination, and it is essential that you follow them precisely. If you do not understand the specific directions, ask the proctor for an explanation.

When marking your answers on the answer sheet, you must use a pencil filled with the special scoring machine lead. Make your marks thus:

1. Solid black marks are made by going over each mark two or three times and by pressing firmly on your pencil.
2. If you change your mind, erase your first mark completely.
3. Make no unnecessary marks in or around the dotted lines. Do not rest your pencil on a lettered space while deciding which space to mark.
4. Keep your answer sheet on a hard surface while marking your answers.
5. Make your marks as long as the pair of dotted lines.
6. Make one mark and only one mark after each answer sheet number. Your score will be reduced by an amount equal to the number of extra marks on your answer sheet.
7. You are expected to answer every item. If you are not sure of the answer to an item, put down the answer that seems most likely to you.

Fifty minutes will be allowed for this examination. When you have finished, turn in the examination booklet and the answer sheet.
After the number on the answer sheet which corresponds to that of each of the following exercises, blacken one lettered space to designate the correct answer.

1. An aviator flies from New York to Chicago, Illinois, consuming 3 hours in the journey. If he leaves New York at 11:00 A.M. (Eastern Standard Time) on May 7, at what time (Central Standard Time) will he arrive in Chicago?
   A. 12:00 P.M., May 7.
   B. 2:00 P.M., May 7.
   C. 3:00 P.M., May 7.
   D. 4:00 P.M., May 7.
   E. 1:00 P.M., May 7.

2. It is 6:00 P.M. Monday in Budapest, Hungary (19° E Longitude). At the same instant it is 3:00 A.M. Tuesday in Brisbane, Australia, whose location must therefore be
   A. 75° E.
   B. 154° W.
   C. 116° W.
   D. 154° E.
   E. 64° E.

3. At the same instant that it is 2:00 P.M. Wednesday in Chicago (88° W Longitude) the time in Ankara, Turkey (33° E Longitude), is nearest
   A. 6:00 A.M., Wednesday.
   B. 8:00 P.M., Wednesday.
   C. 10:00 P.M., Wednesday.
   D. 10:00 A.M., Wednesday.
   E. 4:00 A.M., Tuesday.

4. The sun is at its highest point in the sky for the day when the captain of the ship notes that, at that instant, it is noon Greenwich time. The ship's position (longitude) relative to the east and westerly direction is
   A. 180° longitude.
   B. 90° W longitude.
   C. 45° E longitude.
   D. 0° longitude.
   E. indeterminate.

5. The sidereal day is measured by
   A. the interval between two successive transits of the center of the sun across the celestial meridian.
   B. the time required for one rotation of the earth as measured with respect to the sun.
   C. the time required for one rotation of the earth as measured by the moon.
   D. the interval between two successive transits of a certain star across the meridian.
   E. none of the above.

6. There is a difference of approximately four minutes in the lengths of the solar and sidereal days. This difference can be explained as being due to
   A. the rotation of the earth.
   B. the revolution of the earth and the short distance separating the earth and the sun.
   C. the movements of the stars.
   D. precessional motion of the earth.
   E. parallactic displacement.

7. Solar days are not all of equal length because
   A. all mean solar days are of equal length.
   B. the earth's axis of rotation is not perpendicular to the ecliptic.
   C. it is too difficult to measure precisely two successive transits of the center of the sun across the meridian.
   D. the orbital speed of the earth varies during the year.

8. The North Star changes its apparent position in the sky during the night only slightly because
   A. the axis of the earth is tilted.
   B. it is always on the meridian.
   C. it is so distant from the earth.
   D. it is in line with the earth's axis.
   E. it is at an altitude of 42° when observed from Chicago.
Exercises 9 - 14 pertain to the above diagram.

9. The entire region in complete darkness for at least one day is that
   A. between the Tropic of Capricorn and the Antarctic Circle.
   B. between the equator and the Tropic of Cancer.
   C. south of the Antarctic Circle.
   D. at the Equator.
   E. north of the Arctic Circle.

10. One week later than that shown in the diagram, the period of daylight in the northern hemisphere will be (A. shorter; B. longer; C. the same).

11. The time indicated is
   A. the summer solstice.
   B. the vernal equinox.
   C. the autumnal equinox.
   D. the winter solstice.
   E. none of the preceding.

12. At this position the earth is
   A. at its closest distance to the sun.
   B. just beyond its closest distance from the sun.
   C. at its greatest distance from the sun.
   D. at its average distance from the sun.
   E. just before its greatest distance from the sun.

13. Lengths of daylight and darkness are almost equal at
   A. the Tropic of Capricorn.
   B. all points on the earth.
   C. the Arctic Circle.
   D. the Tropic of Cancer.
   E. the Equator.

14. To observers in the northern hemisphere the length of daylight is of
   A. minimum duration.
   B. maximum duration.
   C. a value between its maximum and minimum duration.

15. Suppose that the earth's axis was tilted 23 1/2° in the opposite direction, but nothing else was changed.
   A. Chicago would have the summer solstice on December 21.
   B. Chicago would have no day and night.
   C. People in Chicago would never see the sun.
   D. Chicago would have no seasons.
   E. People in Chicago would never see the moon.

16. As the moon revolves around the earth, people on the earth see only one side of it. This is true because the moon
   A. does not rotate at all on its axis.
   B. has the same rate of rotation as the earth.
   C. rotates once with respect to the earth during each revolution.
   D. rotates in a direction opposite to that of the rotation of the earth.
   E. is illuminated only by light from the sun.
18. Observations of meteors are useful in determining the
   A. height of the earth's atmosphere.
   B. weather, hence, the term "meteorology."
   C. amount of oxygen in the atmosphere.
   D. temperature of the stratosphere.
   E. amount of helium in the ionosphere.

19. Total eclipses of the sun occur only when the moon is new. Why is there not a total eclipse of the sun by the moon once each month?
   A. The axis of the earth is tilted.
   B. The orbit of the moon is too eccentric.
   C. Two solar eclipses can occur during the same month.
   D. The distance between the earth and the sun varies during the year.
   E. The orbits of the moon and the earth are not in the same plane.

20. Why is there not a total eclipse of the sun by the moon once each month?
   A. The axis of the earth is tilted.
   B. The orbit of the moon is too eccentric.
   C. Two solar eclipses can occur during the same month.
   D. The distance between the earth and the sun varies during the year.
   E. The orbits of the moon and the earth are not in the same plane.

21. The earth's rotation about its axis has a wobble. The axis describes a 23° cone once every 26,000 years. This motion is called (A. retrogression; B. protrusion; C. progression; D. precession; E. propulsion).

For each of the following items, blacken the one lettered space which indicates that the item would be true if the
   A orbit of the earth were a circle rather than an ellipse
   B orbit of the moon were exactly in the same plane as the orbit of the earth
   C earth were not inclined on its axis
   D distance of the moon from the earth were twice as great
   E earth were a perfect sphere

(Assume that only one of the above imaginary conditions occurs at a time.)

22. The celestial equator and the ecliptic would be identical.

23. Solar days would have the same length every day in the year.

24. An eclipse of the sun would occur each month.

25. The tides would be much lower.

26. The earth would have no seasons.

27. The earth would have no seasons.

28. Night and day would be of equal length in all latitudes all year long.

For each of the following items, blacken one lettered space to designate that the item best supports the fact that
   A the earth is spherical
   B the earth rotates on its axis
   C the earth revolves about the sun
   D the earth's orbit is elliptical

29. Star trails observed about the zenith from positions near the North Pole are nearly circular.

30. The earth is nearer the sun in January than it is in June.

31. The masts of an approaching ship become visible before the hull can be seen.

32. The apparent or observed diameter of the sun as seen from the same location on the earth varies slightly during the year.

33. Freely falling bodies fall a little to the east of the place directly beneath the point from which they are released.

34. Except at the equator the Foucault pendulum appears to change its plane of swing.

35. During the year near stars appear to move with respect to more distant stars.
For each of the following items, blacken one lettered space to indicate that the item is evidence or argument which has actually been used:

- A to support the geocentric theory of Ptolemy in former times
- E to support the heliocentric theory
- C in neither or both ways, since the phenomenon described would always have appeared adaptable to either theory

36. At different times of the year the nearer stars are seen in slightly different positions relative to the more remote stars.

37. At different times of the year all the stars are seen in positions slightly behind or ahead of the positions predicted for them.

38. From one day or night to another, the planets and the sun are seen rising in the east and setting in the west, and seeing is believing.

39. When observed night after night for many months, it is evident that the general motion of the planets is toward the east.

40. When observed for a few weeks, Mars appears to describe a thin loop in the sky, which may be explained as a small circle viewed edgewise.

41. Observed from the earth, Mercury and Venus exhibit phases like the moon's.

42. Jupiter has four satellites visible in a small telescope which revolve about it from west to east in the plane of the ecliptic, like a small solar system.

43. Mars' "backward" motion in its orbit can be explained by saying that the earth overtakes and passes it.

44. Objects thrown straight upward into the air fall back to the same spot on the surface of the earth, which does not move on and leave them behind.

45. The phases of the moon prove that the moon revolves about the earth.

46. As commonly observed, the stars remain in fixed positions relative to each other.

47. The observed motions of the heavenly bodies are essentially their actual motions.

48. The speed with which a heavenly body is observed to move relative to the "fixed" stars is a clue to its distance from the observer: the faster it appears to move, the closer it must be to the earth.

From left to right below are the names of the planets in order of their distances from the sun. The inferior planets are labeled A, the superior planets B, the inner planets C, and the outer planets D.

After each item number on the answer sheet, blacken the one lettered space which designates the group of planets to which the item correctly refers. If the item refers to all of the planets, blacken space E.

<table>
<thead>
<tr>
<th>Sun</th>
<th>Mercury</th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
<th>Jupiter</th>
<th>Saturn</th>
<th>Uranus</th>
<th>Neptune</th>
<th>Pluto</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>C</td>
<td>E</td>
<td>B</td>
<td>D</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

49. Sun is at a focus of their elliptical orbits.

50. Obey the Keplerian laws of motion.

51. Large in mass, but low in density.

52. Periods of revolution greater than one earth year.

53. Are never seen at midnight.

54. To an observer on the earth, exhibit phases like the moon.

55. Orbital speeds minimum when farthest from the sun.
For each of the following items, blacken one lettered space to indicate that the item is true for
A an observer on Venus
B an observer on Mars
C both observers
D neither observer

(Assume that clouds do not interfere with the observations.)

56. The earth can never be seen at midnight for the observer.

57. The observer's planet overtakes and passes the earth as both revolve about the sun.

58. Mercury appears to shine by reflected light.

59. The earth exhibits a cycle of phases comparable to that of the moon.

60. So many clouds appear in its atmosphere that it was necessary to make the assumption stated in the directions above.

61. By traveling about on the surface of this planet, the observer can determine whether or not there really are canals.

After each answer sheet number, blacken one lettered space to designate the correct answer.

62. A small metal box, partially exhausted of air and hermetically sealed, is connected through a series of levers to a pointer which moves over a graduated scale with variation in air pressure. This instrument is useful in
A. measuring altitude only.
B. the prediction of weather only.
C. measuring altitude and in the prediction of weather.
D. determining relative humidity.
E. none of the above ways.

63. The temperature is read by means of a thermometer. Then the bulb of the thermometer is wrapped with a piece of dampened cloth and shortly thereafter the thermometer is read again. It is observed that the new temperature reading is much less than the first. It is evident that
A. the relative humidity is low.
B. the relative humidity is high.
C. further data are needed in order to determine whether the relative humidity is high or low.

64. The N.E. trade winds blow toward the southwest while the S.E. trade winds blow northwest. This is true
A. because the earth rotates toward the west.
B. because the anti-trade winds are deflected eastward.
C. because the earth rotates toward the east and it is hot at the equator.
D. only because the "horse latitudes" are regions of low pressure while there is a region of high pressure along the equator.

65. Variation in temperature from one season to another in a given location on the earth's surface is most closely related to variation in
A. the distance of the sun.
B. orbital speed of the earth.
C. direction of the wind.
D. altitude of the sun at noon and duration of daylight.
E. length of seasons in the given location.

66. Which of the following best accounts for the fact that warm air rises above cold air in the "front"?
A. Warm air contains less moisture and therefore is lighter.
B. Warm air has a higher temperature.
C. Warm air moves faster.
D. Warm air is less dense than cold air.
67. Why does precipitation occur as warm air rises over the cold air "wedge"?
   A. The warm air takes no more water vapor from the cold air than it is able to hold.
   B. Warm air cannot hold as much water vapor as cold air can.
   C. The rising air cools and loses some of its capacity for holding moisture.
   D. The warm air expands as it rises and loses all of its water vapor.

68. If Lake Michigan were to completely vanish, winters in Chicago would
   A. remain unchanged.
   B. become colder.
   C. become more mild.
   D. disappear completely.

69. When we have a sea breeze
   A. there is a strong westerly wind aloft.
   B. there is a strong southerly wind aloft.
   C. the land is warmer than the sea.
   D. the sea is warmer than the land.
   E. the land and water have reached the same temperature.

70. During a recent hurricane which travelled northwest over Miami, Florida, the winds were northeasterly steadily increasing to a velocity of over 100 mi/hr. Suddenly the winds died out completely.
   A. The hurricane had passed over and all danger was over.
   B. The hurricane had "died out" completely.
   C. The "eye" of the storm was overhead.
   D. The front had passed.
   E. A high pressure had destroyed the hurricane.

71. The forecast for the night was clear skies and very low temperatures, but instead the sky is overcast. Since this is the case your expectation in regard to temperature would be
   A. colder than predicted.
   B. about as forecast.
   C. warmer than forecast.
   D. no way of really knowing.

72. The correct answer to the preceding exercise is based upon the fact that
   A. there isn't any real association between clouds and temperature.
   B. the cold front went by faster than expected.
   C. clear skies would permit absorption of heat.
   D. clouds prevent heat loss to space.
   E. if the winds are northerly it must be very cold.

73. The circulation of air in the atmosphere is largely due to two factors. One of these is solar radiation, the other is the
   A. plane of the ecliptic.
   B. green-house effect of the clouds.
   C. distance to the ionosphere.
   D. earth's rotation.
   E. acceleration due to gravity.

74. The fact that our hottest weather does not come in June when the sun is highest at noon is due chiefly to
   A. the fact that the earth is nearest the sun in June.
   B. the fact that the earth is farthest from the sun in June.
   C. the precession of the equinoxes.
   D. the inclination of the equator to the ecliptic.
   E. it takes time to warm the earth's surface and atmosphere.
For each of the following paired items, blacken the one lettered space which designates that

A the item at the left is of greater magnitude than the item at the right
B the item at the right is of greater magnitude than the item at the left
C the two items are of the same magnitude, or it cannot be said that one is greater than the other.

75. Extent to which the trade winds south of the equator blow toward the northwest. 
76. Extent to which the "horse latitudes" are belts of high pressure.
77. Extent to which dry weather is characteristic of the equatorial zone.
78. Tendency of winds in the zone between 30° N. and 60° N. to blow from the west.
79. Usual height of air masses moving from the equator toward the poles.
80. Extent to which during summers in the temperate zones, high pressures and low temperatures characterize large land areas.
81. The height of the mercury in a barometer at the foot of a mountain.
82. Probability of steady rainfall given the approach of a cold front.
83. Probability of a thunderstorm given the approach of a cold front.
84. Steepness of the slope of a warm front.
85. Extent to which very high feather-like clouds indicate the approach of a cold front.

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When you have finished the test go over each of your marks again with the special pencil to make each mark solid, black and glossy. Erase all superfluous marks on the answer sheet no matter how tiny.

YOUR SCORE WILL BE REDUCED BY AN AMOUNT EQUAL TO THE NUMBER OF EXTRA MARKS ON YOUR ANSWER SHEET.
DIRECTIONS: Print your name (last name first), the title of the examination, the name of your college, and the date on the designated blanks on the answer sheet.

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A B C D E
100.
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1. Solid black marks are made by going over each mark two or three times and by pressing firmly on your pencil.

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6. Make one mark and only one mark after each answer sheet number. Your score will be reduced by an amount equal to the number of extra marks on your answer sheet.

Two hours will be allowed for this examination. When you have finished, turn in the examination booklet and the answer sheet. Be sure to sign the record form.
After the number on the answer sheet which corresponds to that of each of the following exercises, blacken one lettered space to indicate the correct answer.

1. The initial step in the general pattern of scientific thinking is the
   A. setting up of an hypothesis.  
   B. collecting of observational or experimental data. 
   C. application of a general principle.  
   D. recognition and definition of a problem.  
   E. testing of an hypothesis.

2. Numerous observations and experiments have shown that "all chemical compounds have a definite composition." The quoted words best exemplify
   A. a scientific law or generalization.  
   B. an hypothesis. 
   C. a result of deductive reasoning. 
   D. an assumption. 
   E. reasoning from the abstract to the concrete.

3. From numerous observations that applications of pressure to various gases always result in proportionate decreases in their volumes, Robert Boyle concluded that "the volume of a gas varies inversely with the pressure." This best illustrates the
   A. formulation of an hypothesis. 
   B. deduction from a scientific law. 
   C. reasoning from the abstract to the concrete. 
   D. testing of an hypothesis. 
   E. use of inductive reasoning.

4. Which of the following is most destructive to a theory?
   A. The opposition of a great scientist.  
   B. A new and conflicting theory. 
   C. A carefully formulated subjective opinion. 
   D. New facts contradicting the theory. 
   E. A new hypothesis in opposition to the theory.

5. Which of the following best expresses the purpose of experimentation?
   A. The application of a general law to a new situation. 
   B. The obtaining of new evidence to test an hypothesis. 
   C. The obtaining of evidence which will support a theory. 
   D. The obtaining of evidence which will disprove a theory. 
   E. The elimination of subjective thinking from the behavior of a scientist.

6. A scientist thinks that he understands why a certain cause produces a certain effect, but he refuses more than tentatively to accept his explanation until he has collected adequate data. It is evident from the above alone that this scientist possesses
   A. scientific knowledge.  
   B. common sense. 
   C. scientific attitude. 
   D. the correct solution to his problem. 
   E. a willingness to rationalize.

7. When one evolves a new explanation of why a certain cause produces a certain effect with the idea of testing the explanation by means of data, it is most appropriate to call the explanation
   A. a deduction. 
   B. a scientific law. 
   C. an example of inductive reasoning. 
   D. a general theory. 
   E. an hypothesis.
READ THE FOLLOWING SELECTION CAREFULLY. It is taken from a book called "Life on the Mississippi."

(1) "In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. (2) Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Blacken one lettered space to designate the best answer.

8. Statement 1 about the shortening of the Lower Mississippi is
   A. nothing more than a guess.
   B. presumably true because rivers usually become shorter as they grow older.
   C. presumably true because the necessary measurements could have been made in the period indicated.
   D. presumably false because everyone knows that the Mississippi is lengthening instead of shortening.
   E. presumably false because the necessary measurements could not have been made by a single individual.

9. The length of the Lower Mississippi a million years ago as given in statement 2 is
   A. a fact.
   B. the result of reasoning on the basis of extension of data.
   C. a hypothesis to be tested.
   D. the result of testing.
   E. evidence upholding or disproving a hypothesis.

10. Statement 2 was obtained by
    A. making a generalization on the basis of facts.
    B. inductive reasoning from a previously known generalization.
    C. simple calculation without assumptions.
    D. calculation assuming a constant rate of change.
    E. inference from geological studies.

11. The validity of statement 2 is
    A. disproved by the fact that the action described is obviously impossible.
    B. impossible to prove or disprove, because one cannot live the length of time indicated.
    C. impossible to prove or disprove, because no instruments are available to measure such distances or periods of time.
    D. impossible to check, because no geological data are available covering the period of time mentioned.
    E. impossible to check experimentally by direct measurements.

12. Statement 2 is probably
    A. true, because by the process of extrapolation statement 2 follows from statement 1.
    B. true, because the statement is obvious.
    C. false, because no one ever saw the Lower Mississippi a million years ago.
    D. false, because other geological data are ignored.
    E. difficult to prove either true or false.

13. The 242-mile shortening of the Lower Mississippi referred to was probably caused by
    A. erosion of that portion sticking "out over the Gulf of Mexico like a fishing rod."
    B. widening of the Gulf of Mexico through sinking of its shores.
    C. an increase in the width of the Mississippi.
    D. a decrease in the number of curves and a straightening of the river channel.
    E. a decrease in the amount of water carried by the river.

14. A science teacher might use this article to
    A. show that one should not make wholesale conjectures based on incomplete data.
    B. show that he understands the geology of the Lower Mississippi.
    C. show that science is fascinating.
    D. show the reaction of a calm person, who is neither blind nor idiotic.
    E. present a history of the Lower Mississippi.
After each exercise number on the answer sheet, blacken one lettered space to designate the correct answer.

15. A certain fossil is very abundant and easy to identify. It has a wide geographic distribution. The organism producing the fossil has not changed significantly during the last three geological eras. This fossil is not a good index fossil because
   A. it has wide geographic distribution.
   B. the ease with which it can be identified may be misleading.
   C. it will appear the same in successive strata.
   D. of all of the above reasons.
   E. of none of the above reasons.

16. The present shape of the Great Lakes is due chiefly to
   A. down-washing of the earth's crust.
   B. glacial gouging of rock strata of varying hardness.
   C. water from the melting glacier.
   D. alternate elevation and submergence of the region.
   E. side-slipping of the Niagara limestone from Niagara Falls to Lake Michigan.

17. Hundreds of years ago natural levees in the lower Mississippi Valley were about 3 ft. high. Man has built these levees to greater heights in an attempt to retain seasonal flood waters. One must conclude that more water is being diverted into the river channel because man has
   A. cut down huge forests.
   B. plowed under pasture lands adjacent to the river valleys.
   C. diverted more water into the river valleys.
   D. filled in swamp lands adjacent to the river valley.
   E. done two or more of the above things.

18. An unconformity in rock strata as shown in the diagram indicates
   A. deposition of large quantities of unsorted material.
   B. that a transitory feature definitely existed in the area at one time.
   C. a long period of erosion followed by submergence and sedimentation.
   D. that igneous rock is usually beneath the sedimentary layers.
   E. that mountains have been produced at one time due to differential erosion.

19. In a series of sedimentary rock layers
   A. a layer of limestone always is beneath the layer of sandstone.
   B. the most recent layer of the series is sandstone.
   C. the most recent layer is the top layer.
   D. the layer at the bottom of the series is the most recent layer.
   E. nothing can be said about the time sequence of the layers in the series.

20. If an igneous intrusion has passed through a layer of sedimentary rock in a series of such layers
   A. the intrusion is probably younger than the layer through which it passed.
   B. the intrusion is probably older than the layer through which it passed.
   C. a geyser is likely to be formed.
   D. an unconformity will probably result.
   E. no conclusion can be drawn as to the time sequence of the layer of sedimentary rock through which the intrusion passed and the intrusion.

21. The most useful information regarding the composition of the interior of the earth can be derived from earthquakes since
   A. different types of earthquake waves travel at different speeds.
   B. earthquake waves travel at different rates through different media.
   C. earthquakes usually release materials from within the earth which can be studied as to composition.
   D. the earth is solid throughout.
   E. the amplitude of vibration varies with the type of waves.
In a Chicago quarry the walls are thick horizontal layers of a pale gray rock which contains many tiny shells of marine animals. This rock dissolves slowly in water containing carbon dioxide. It is probably
A. granite.
B. limestone.
C. basalt.
D. sandstone.
E. shale.

In a certain region, a series of sedimentary rock strata has been subjected to extensive folding. Therefore
A. metamorphic rock is probably present in the area.
B. any young valley in the area would be converted to a more mature stage.
C. igneous rock must be present in the form of sills and dikes.
D. the sedimentary rock has been converted by pressure into clay and soil.
E. the land surface is now thoroughly drained by a system of new young valleys.

The land surface as found in a mature region
A. is mostly covered with steep sided canyons.
B. is mostly covered with original upland.
C. shows such depositional features as moraines.
D. is poorly drained by a sluggish system of rivers.
E. is thoroughly drained by a complex system of tributary rivers.

In California, roads and stream beds are broken when they cross a line several hundreds of miles long. They are displaced some ten feet to one side when they cross the line. This is due to (A. volcanic action; B. landslides; C. erosion; D. faulting; E. slumping).

The entrenched meanders and rejuvenated streams of the present Appalachian Mountains are evidence of
A. the occurrence of crustal re-elevation.
B. the formation of a new geosyncline.
C. glacial action.
D. slipping and faulting.
E. the presence of alternate layers of hard and soft rocks.

Which of the following characteristics would enable you to recognize the deposits of a continental ice sheet?
A. Sediments unsorted with respect to size.
B. Sediments containing many different types of rock, spread over a large area.
C. Sediments having an irregular, hilly, undrained topography.
D. All of the above.
E. None of the above.

The deposition of sediment by a stream increases as the
A. velocity increases.
B. velocity decreases.
C. particle size decreases.
D. volume of water increases.
E. slope of the bed increases.

Which one of the following would offer the best basis for concluding that a certain layer of shale in New York was deposited at the same time as one in California?
A. They are the same distance below the surface.
B. They contain similar fossil remains.
C. They have the same chemical composition.
D. They are both sedimentary rocks.
E. Each one is between two sandstone layers.

The existence of a flood-plain along a stream indicates that
A. the stream must be more than 15 million years old.
B. the stream has cut down to very hard rock.
C. the stream's rate of downcutting has decreased to almost, but not quite, zero.
D. the rate of weathering has increased markedly, and rather rapidly.
E. the stream is very old, and will shortly die for lack of water.

Caverns and underground tunnels occur in limestone strata when ground water (A. contains dissolved minerals; B. has been heated by contact with hot masses of rock; C. emerges to form a spring; D. attacks a recent igneous intrusion; E. contains dissolved carbon dioxide).
A rock formation has all of the following observed characteristics:
(W) It is stratified and crossbedded
(X) Its chemical composition is almost pure SiO₂
(Y) It is not a metamorphic rock
(Z) It contains fossil trilobites

32. The rock (A. is quartzite; B. is not quartzite; C. may or may not be quartzite, i.e., it is impossible to tell).
33. This conclusion follows from (A. characteristic W; B. characteristic X; C. characteristic Y; D. characteristic Z; E. insufficient data).
34. The rock (A. is limestone; B. is not limestone; C. may or may not be limestone, i.e., it is impossible to tell).
35. This conclusion follows from the observation of (A. characteristic W; B. characteristic X; C. characteristic Y; D. characteristic Z; E. insufficient data).
36. The rock (A. is sandstone; B. is not sandstone; C. may or may not be sandstone, i.e., it is impossible to tell).

The statements below represent the effects of certain causes. After the first of the two numbers following the statement, blacken the one lettered space which designates the cause. After the second number blacken the one lettered space which designates the rock, mineral, or geological formation involved in the cause and effect relationship.

Statement: Unsorted material containing granite particles is found over limestone bed rock.
37. (A. Glaciers; B. rivers; C. ground water; D. volcanic activity; E. wind.)
38. (A. Alluvial fan; B. delta; C. loess; D. moraine; E. outcrop.)

Statement: An amphitheater-like depression is close to the top of a certain high mountain.
39. (A. Wind; B. running water; C. ice; D. oxidation, hydration, and carbonation; E. atmosphere.)
40. (A. Cirque; B. canyon; C. sinkhole; D. crevasse; E. pothole.)

Statement: A rock containing feldspar, quartz, and mica assumes a banded appearance.
41. (A. Weathering; B. ground water; C. sedimentation; D. carbon dioxide; E. diastrophism.)
42. (A. Shale; B. gneiss; C. conglomerate; D. quartzite; E. slate.)

Statement: A certain rock contains parallel scratches on its face.
43. (A. Wind; B. running water; C. ice; D. wind and ice; E. waves.)
44. (A. Geode; B. striae; C. stalactites; D. metamorphosed rock; E. concretions.)

Statement: Thick deposits of fine material from thirty to one hundred feet thick occur without horizontal stratification.
45. (A. Glacier; B. rivers; C. ground water; D. wind; E. rain.)
46. (A. Talus; B. till; C. loess; D. delta; E. alluvium.)

Statement: A certain rock is hollow on the inside and partly filled with crystals of quartz.
47. (A. Ground water; B. carbonated water; C. hot water; D. steam expansion; E. replacement.)
48. (A. Concretion; B. stalagmite; C. travertine; D. geode; E. cirque.)
49. In the diagram there is no example of (A. a recent period of diastrophism; B. an ancient period of diastrophism; C. a recent period of gradation; D. an ancient period of gradation; E. a recent volcanic disturbance).

50. In the diagram there is no example of (A. a tension fault; B. a thrust fault; C. an unconformity; D. an anticline; E. a syncline).

51. Formation IV was made by (A. wind erosion; B. running water; C. ground water; D. ice; E. waves).

52. The rock in III is most likely to be (A. limestone; B. granite; C. quartzite; D. conglomerate; E. marble).

53. The rock in I is most likely to be (A. limestone; B. slate; C. obsidian; D. granite; E. gneiss).

54. The most ancient event labeled in the diagram, with the possible exception of III, is the (A. formation of XX1; B. formation of IV; C. formation of YY1; D. formation of II; E. formation of I).

55. The most recent event labeled in the diagram is the (A. formation of XX1; B. formation of IV; C. formation of ZZ1; D. formation of YY1; E. folding of the rocks in II).

56. XX1 was formed before (A. YY1 was made; B. the rocks in I were deposited; C. ZZ1 was made; D. the rocks in II were deposited; E. the strata in II were folded).

57. The fact that remains of marine animals have been found far inland is evidence of (A. volcanism; B. diastrophism; C. gradation; D. erosion; E. exfoliation).

58. It is possible to tell whether a rock has been formed close to the surface or at great depths by its (A. color; B. crystal size; C. composition; D. acidity).

59. A sedimentary rock whose sediments consist of clay or mud is known as (A. shale; B. limestone; C. chert; D. conglomerate; E. sandstone).

60. The metamorphic equivalent of granite is (A. marble; B. quartzite; C. a gneiss; D. a schist; E. a slate).
After each exercise number on the answer sheet, blacken one lettered space to designate the correct answer.

61. If the glass tubing of the barometer were punctured at point A in the drawing, the mercury in the column would
   A. remain at its present height.
   B. fall distance B and rise toward C.
   C. slowly rise in the tube and overflow at A.
   D. no longer weigh 30 pounds per cubic inch.

62. At an altitude of 24,000 feet the height of a mercury column in a barometer is 11.80 inches, while at sea level it is 29.92 inches. One can infer from these data alone that
   A. there is insufficient oxygen at 24,000 feet to support life.
   B. the air contains much less than 20 per cent oxygen by volume.
   C. there is almost no carbon dioxide in the air.
   D. the weight of the air above 24,000 feet is about 40 percent of the weight of the air above sea-level.
   E. water will not boil at this altitude.

63. At sea level, the weight of a column of mercury of one square inch cross sectional area in such a barometer is approximately
   A. 30 pounds.
   B. 15 pounds.
   C. one-half pound.
   D. 30 ounces.
   E. 15 ounces.

64. Moving air seems cooler to a person than still air, because
   A. moving the air gives it a lower temperature.
   B. moisture from the body is evaporated more rapidly.
   C. moving air on the face reduces evaporation.
   D. moving air has the greater specific heat.
   E. still air has the greater specific heat.

65. St. Louis and Chicago have about the same average minimum low temperatures during the winter even though Chicago is about 300 miles farther north. One explanation is that
   A. St. Louis is closer to sea-level.
   B. 300 miles is insufficient to note changes in average minimum low temperatures.
   C. Lake Michigan loses heat slowly.
   D. river towns have mild winters.

66. If the temperature of a certain time of day is 85°F. and the relative humidity is 94 percent, A. relative humidity will have to decrease before rain will fall.
   B. it is sure to be raining.
   C. any increase in temperature will be accompanied by an increase in relative humidity.
   D. an increase in temperature of 15° will cause rain.
   E. it will rain if the temperature decreases sufficiently.

67. What is meant by saying that the relative humidity on a certain day is 80%?
   A. That water vapor in the air constitutes 80% of the air.
   B. That the air contains 80 parts of water to 100 parts of dry air.
   C. That the air contains 80% of the water vapor it is capable of holding.
   D. That the air contains the same amount of water that it would contain at 80°F Fahrenheit.
68. Clouds form when
A. there is an increase in the temperature of the air.
B. the center of an air mass arrives at a given area.
C. wind velocities reach a certain critical value.
D. moist air rises to higher elevations.
E. the air has absorbed a certain amount of heat from the sun.

69. Lines on a weather map connecting points of equal atmospheric pressure are called
A. isotherms.
B. isobars.
C. fronts.
D. cyclones.
E. anticyclones.

The diagram below is a vertical cross section of weather conditions existing in the Middle West during the late days of the month of March. Immediately below the diagram is a list of weather conditions existing at the various cities appearing on the diagram. After the number on the answer sheet which corresponds to that of each of the following items, blacken the one lettered space which designates the city at the right to which the item correctly refers.

   A. Joliet, Illinois

   B. Gary, Indiana

   C. Fort Wayne, Indiana

   D. Toledo, Ohio

   E. Cleveland, Ohio
After each item number on the answer sheet, blacken space
A if the statement is true of a high pressure area
B if the statement is true of a low pressure area
C if the statement is true of both a high pressure and a low pressure area
D if the statement is true for neither a high pressure nor a low pressure area

75. In the Northern Hemisphere, the wind in such an area is moving as indicated in the diagram.

76. An area in which the air is rising as one goes toward the center.

77. When the air in such an area has come down from the north we experience cool and dry weather.

78. All regions covered by such areas will have the wind blowing from the same direction.

79. The general direction in which the air in such an area moves is due to the rotation of the earth.

80. Such an area is more often than not associated with cloudy weather and rain.

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After the number on the answer sheet which corresponds to that of each of the following paired items, blacken one lettered space to indicate that
A the item in Column I is greater than the item in Column II
B the item in Column I is greater than the item in Column II
C both items are equal, or it cannot be said that one is greater than the other

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent to which dry weather is characteristic</td>
<td>Extent to which rainy weather is characteristic</td>
</tr>
<tr>
<td>of the equatorial zone.</td>
<td>of the equatorial zone.</td>
</tr>
<tr>
<td>Tendency of winds in the zone between 30° N.</td>
<td>Tendency of winds in the zone between 30° S.</td>
</tr>
<tr>
<td>and 60° N. to blow from the west.</td>
<td>and 60° S. to blow from the west.</td>
</tr>
<tr>
<td>The height of the mercury in a barometer at</td>
<td>The height of the mercury in the barometer</td>
</tr>
<tr>
<td>the foot of a mountain.</td>
<td>when carried to the top of the mountain.</td>
</tr>
<tr>
<td>Extent to which during summers in the</td>
<td>Extent to which during summers in the</td>
</tr>
<tr>
<td>temperate zones, high pressures and low</td>
<td>temperate zones, low pressures and high</td>
</tr>
<tr>
<td>temperatures characterize large land areas.</td>
<td>temperatures characterize large land areas.</td>
</tr>
</tbody>
</table>

For each of the following items, blacken one lettered space to indicate that the phenomenon described in the item is due to
A the rotation of the earth on its axis
B the revolution of the earth about the sun
C the inclination of the earth's axis
D a combination of the revolution of the earth about the sun and the inclination of the earth's axis
E the somewhat flattened, but essentially spherical shape of the earth

85. Variation in altitude of the Polar Star with changing latitude.
86. Apparent eastward motion of the sun among the stars.
87. The increasing area of the earth which becomes visible as one ascends in a balloon.
88. The succession of day and night.
89. The succession of the seasons.
90. Variation in the length of day and night during the year (except at the equator).
91. The apparent back and forth motion of the near stars with respect to the more distant ones.
92. The westward motion of the polar winds.
93. Change in angle at which the sun's rays fall on Chicago at noon on different days.
95. Which of the following is the best proof that the earth rotates on its axis, in other words, the observation cannot plausibly be explained in some other way?
   A. The sun rises in the east and sets in the west every day.
   B. Star trails circle about the North Star if the camera is pointed at the North Star.
   C. Stars are on the meridian a little later each night.
   D. The plane of swing of a long pendulum changes as the hours go by in all places on earth except at the equator.
   E. Nearby stars shift in their direction from the earth more than do the distant stars.

96. An observer in Minnesota notes that the North Star is 50° above the horizon. The observer's latitude is
   A. 50° N.
   B. 40° N.
   C. 0° N.
   D. indeterminate.

97. If an individual were able to get to the moon, he would find certain conditions which would be detrimental to life. In the following, all but one are experiences the observer might encounter. Select the one possibility that you know is in error.
   A. There would be no oxygen to support life.
   B. There would be extreme temperature changes from day to night.
   C. Only one side of the earth would ever be visible from the moon.
   D. There would be a small gravitational effect as compared to the earth.
   E. The earth would be visible as a large reflector of sunlight.

98. Suppose that men in a space ship are able to land on the moon when it is a new moon and on the side toward the earth. Which of the following would be true?
   A. The earth would appear like a very large full moon.
   B. The moon's surface around their landing place would be totally dark.
   C. The earth would appear faintly illuminated by moonlight.
   D. The earth would look like a quarter moon.
   E. The moon's surface around their landing place would be in bright sunlight.

99. The sun shines on the North Pole area day and night for almost six months every year yet it is extremely cold there during this time. The reason for this is that
   A. there are large areas of water which are difficult to heat up.
   B. there are large land areas which are difficult to heat up.
   C. the other six months there is no sun at all,
   D. at no time is the altitude of the sun very high.
   E. the rotational speed of the pole area is much smaller than that of the equatorial area.

100. It is commonly said that people in general in ancient times believed that the earth is flat. If ancient astronomers had also believed this, they would have been unable to measure the
   A. altitude of the sun.
   B. time of the solstices.
   C. size of the earth.
   D. time of day.
   E. length of the year.

101. Observation of a full moon as it enters the earth's shadow during an eclipse of the moon is useful in
   A. studying the corona of the sun.
   B. providing evidence that the earth is a sphere.
   C. discovering whether or not the moon has any atmosphere.
   D. determining the distance of the moon from the earth.

102. If one knows only that the sun and moon have very nearly the same angular or apparent size when observed in the sky, it can be concluded that
   A. the sun is much larger than the moon.
   B. the sun is much further from the earth than the moon.
   C. the sun is both much larger and much further away than the moon.
   D. more information is needed to prove that the sun is much larger and further away than the moon.
Exercises 103 to 114 pertain to the above diagram.

103. Which of the following are in the same plane?
   A. The orbit of the earth and the celestial equator.
   B. The orbit of the earth and the equator of the earth.
   C. The orbit of the earth and the ecliptic.
   D. The celestial equator and the equator of the sun.
   E. The axis of the earth in all four positions shown.

104. Which of the following are in the same plane, but not the plane of the correct answer of the preceding exercise?
   A. The equator of the earth and the celestial equator.
   B. The equator of the earth and the equator of the sun.
   C. The ecliptic and the celestial equator.
   D. The equator of the earth and the orbit of the earth.
   E. The celestial equator and the orbit of the earth.

105. At the time of the vernal equinox the earth is in position (A. I; B. II; C. III; D. IV).

106. This is true because at the time of the vernal equinox
   A. the earth is nearest to the point labeled Vernal Equinox.
   B. the sun appears to be at that point in the sky.
   C. only on March 21 are days and nights of equal length all over the earth.
   D. the vernal equinox is the beginning of summer in the northern hemisphere.
   E. on September 23 the earth is between the vernal equinox and the sun.

107. The best time of year for exploration in the antarctic is when the earth is in position (A. I; B. II; C. III; D. IV).

108. To an observer on the earth the sun appears to be on the ecliptic when the earth is in (A. position II only; B. position IV only; C. positions II and IV only; D. positions I and III only; E. any orbital position).

109. Persons located on the Tropic of Cancer see the sun directly overhead when the earth is in position (A. I; B. II; C. III; D. IV).

110. When the altitude of the noonday sun is at a minimum in Chicago, the earth is at position (A. I; B. II; C. III; D. IV).
111. The planes of the celestial equator and the ecliptic intersect at an angle of 23.5° because
A. the orbit of the earth is an ellipse rather than a circle.
B. there are seasons on the earth.
C. the earth's axis is tilted this amount from the plane of its equator.
D. the earth's axis is tilted this amount from a line perpendicular to the plane of its orbit.
E. the Tropics of Cancer and of Capricorn are each 23.5° from the earth's equator.

112. Equal days and nights occur all over the earth when the earth is in
A. position II only.
B. position IV only.
C. positions II and IV.
D. positions I and III.

113. No sunlight reaches inside the antarctic circle when the earth is in position (A. I; B. II; C. III; D. IV).

114. While you are taking this examination, the earth is between positions (A. I and II; B. II and III; C. III and IV; D. IV and I).

115. If the diameter of the earth were twice its present value while the mass remained the same, the weight of an object on the earth's surface would be
A. one-fourth its present value.
B. one-half its present value.
C. the same as its present value.
D. twice its present value.
E. four times its present value.

116. What evidence that the earth revolves about the sun was not available to Tycho Brahe or to Galileo, although both recognized the significance of such evidence?
A. Observation of the phases of Venus.
B. The transit of Venus across the sun's disk.
C. Revolution of the satellites of Jupiter.
D. Fluctuations of the Cepheid variables.
E. Annual parallactic displacement of stars.

117. Venus shows phases like the moon. Which one of the following gives the best explanation of this phenomenon?
A. Venus moves around the sun in an orbit within the orbit of the earth.
B. Venus is smaller than the earth.
C. Venus moves faster than the earth.
D. Venus revolves about the earth.
E. Venus is a satellite of another planet.

118. Observation of irregularities in the orbit of Uranus lead to the discovery of Neptune. The calculations were based on
A. data carefully collected by Tycho Brahe.
B. Kepler's Law of Areas.
C. the Law of Independence of Motions.
D. Newton's First Law of Motion.
E. the Law of Gravitation.

119. Direct observational evidence of the curvature of the earth may be obtained by observing
A. the moon and nearby planets and noting that they are spheres.
B. the motion of a long pendulum, such as the one in the Museum of Science and Industry.
C. star trails at night and noting that they are curves, except at the equator.
D. the shadow of the earth during a partial eclipse of the moon.
E. the size of the sun in the East and its setting in the West.
At times the earth, sun, and moon may be in positions in space along, or nearly along, a straight line through these bodies, although their order may differ from that just given. The same is true of the earth, sun, and a given planet. Select from the first group of answers for items 120 to 124 and from the second group for items 125 to 129.

120. The order during a lunar eclipse.  
A. Sun - moon - earth only  
B. Moon - earth - sun only  
C. Moon - sun - earth  
D. Sun - moon - earth or moon - earth - sun  
E. None of the above orders

121. This is an order which never occurs.  
A. Sun - moon - earth only  
B. Moon - earth - sun only  
C. Moon - sun - earth  
D. Sun - moon - earth or moon - earth - sun  
E. None of the above orders

122. The order during spring tides.  
A. Sun - moon - earth only  
B. Moon - earth - sun only  
C. Moon - sun - earth  
D. Sun - moon - earth or moon - earth - sun  
E. None of the above orders

123. The order during neap tides.  
A. Sun - moon - earth only  
B. Moon - earth - sun only  
C. Moon - sun - earth  
D. Sun - moon - earth or moon - earth - sun  
E. None of the above orders

124. The order when the moon is full.  
A. Sun - moon - earth only  
B. Moon - earth - sun only  
C. Moon - sun - earth  
D. Sun - moon - earth or moon - earth - sun  
E. None of the above orders

125. The order when Venus appears smallest.  
A. Sun - planet - earth  
B. Planet - earth - sun  
C. Planet - sun - earth  
D. None of the above orders

126. The order when Jupiter is in opposition.  
A. Sun - planet - earth  
B. Planet - earth - sun  
C. Planet - sun - earth  
D. None of the above orders

127. The order when Venus transits the sun.  
A. Sun - planet - earth  
B. Planet - earth - sun  
C. Planet - sun - earth  
D. None of the above orders

128. The order when Mars is most easily observed.  
A. Sun - planet - earth  
B. Planet - earth - sun  
C. Planet - sun - earth  
D. None of the above orders

129. An order true only of the inferior planets.  
A. Sun - planet - earth  
B. Planet - earth - sun  
C. Planet - sun - earth  
D. None of the above orders

Read the following selection carefully and then answer the exercises.

A number of science fiction stories, comic strips and motion pictures have dealt with possible future space travel. The situations depicted are not necessarily impossible. The military authorities and scientists of various countries are giving serious consideration to the problems of space travel. Some of these problems have to do with the effects on the human body of the accelerations which it is necessary to attain in order to leave the earth. Others are concerned with the conditions in interplanetary space, and the kinds of ships and equipment which it will be necessary to build in order to travel or exist there. These problems are well-known to writers of science fiction. To make their stories as near to reality as possible they take these problems into consideration. Therefore, all such stories have certain principles in common. The following items are based on these common principles.

130. Space suits are usually shown as equipped with heavy shoes having thick magnetic soles. These serve to  
A. hold the feet downward and the body in an upright position.  
B. neutralize the effect of abnormal magnetic phenomena which occur in space.  
C. increase the wearer's weight.  
D. enable the wearer to operate various instruments by remote controls.  
E. enable the wearer to cling to iron surfaces inside or outside of the ship and avoid floating freely in space.

131. Future travelers, wearing space suits, may sometimes walk about on the outside of a space ship while the ship is moving with uniform velocity through space between the earth and Mars. They will be subject to all of the following hazards except  
A. being struck by meteorites.  
B. becoming dangerously chilled.  
C. being blown off the ship.  
D. being exposed to cosmic rays.  
E. suffering from lack of oxygen.

132. On approaching a planet, the space navigators turn the ship around so that the tail of the ship is pointed toward the surface because  
A. the control room of the ship would otherwise be upside down.  
B. the tail is heavier than the nose.  
C. the tail is not so sharp as the nose, and would not become stuck in the surface so easily in case of an emergency landing.  
D. they wish to be in a position to take off.  
E. they wish to slow their fall by firing their rocket motors toward the surface.
133. If the landing is on the moon the travelers in space suits are shown to carry heavy loads with ease, and to take tremendously long steps while running because
A. of the excitement of being in a new and strange environment.
B. there is less gravitation attraction on the moon than on earth.
C. the earth is pulling them away from the moon.
D. of the absence of air on the moon.
E. they have more energy on the moon.

134. The travelers on the moon see the sun and other stars shining in a black sky because the
A. atmosphere on the moon is dark.
B. moon is nearer the stars.
C. moon possesses no atmosphere.
D. moon's surface is extremely cold.
E. travelers have dark glass in the windows of their space suits.

After each item number on the answer sheet, blacken the one lettered space which designates the word or phrase that would correctly complete the item. Neglect air resistance.

A. Zero
B. Constant, but not zero
C. Increasing at a constant rate
D. Decreasing at a constant rate

135. The acceleration of a freely falling body is ...... .
136. The velocity of a freely falling body is ...... .
137. The acceleration of a car traveling south at a continuous rate of 30 miles per hour is ...... .
138. The acceleration of a car, stopping for a red light at the rate of 5 feet per second per second, is ...... .
139. The velocity of a car moving with an acceleration of 11 feet per second per second is ...... .
140. The velocity of a car, coasting after the motor has been shut off, is ...... .
141. The velocity of a car, when the push of the motor just equals the frictional forces tending to stop the car, is ...... .
142. The acceleration of a cable car being towed up an incline by a motor which turns the cable drum 50 revolutions per minute is ...... .
143. If an object is moving in a given direction at a constant velocity and there is no friction or air resistance, the force is ...... .
144. If the velocity of the object referred to in item 143 is increasing at a constant rate, the acceleration is ...... .
145. If the velocity of the object referred to in item 143 is increasing at a constant rate, the force is ...... .
146. If the acceleration of the object referred to in item 143 is increasing at a constant rate, the force is ...... .
Each of the items below is an application of or is related to one of the laws listed in the column at the right. After each item number on the answer sheet, blacken the one lettered space which indicates the law to which the item refers.

147. When a gun is fired, it will recoil.

148. A car rounding a curve too fast goes off the road on the outside of the curve.

149. When a falling object strikes the earth, its energy of motion is converted into an exactly equivalent amount of heat.

150. The heavier cars must have more powerful engines if they are to have "pick-up" equal to lighter cars.

151. When two bodies are moved so that the distance between them is twice as great as it was before, the force of attraction between them becomes one-fourth of its original value.

152. If one jerks a smooth tablecloth quickly enough, it can be removed without disturbing the heavy dishes on it.

153. The work output of any machine, increased by the work converted into heat by friction, must always be equal to the input.

154. The force with which the sun attracts the earth is exactly equal to the force with which the earth attracts the sun.

A. Every body continues its state of rest or of uniform motion in a straight line, unless it is compelled to change that state by a force.

B. The acceleration imparted to a body is proportional to the force acting and takes place in the same direction as the force applied.

C. To every action there is always opposed an equal reaction; or the mutual actions of two bodies on each other are always equal and opposite.


In the table below the distances traveled each second by objects A, B, C, D, and E are given in feet. Assume that there is no friction.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Second</td>
<td>1</td>
<td>6</td>
<td>16</td>
<td>36</td>
<td>20</td>
</tr>
<tr>
<td>Second Second</td>
<td>3</td>
<td>6</td>
<td>48</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Third Second</td>
<td>6</td>
<td>6</td>
<td>80</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Fourth Second</td>
<td>10</td>
<td>6</td>
<td>112</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>Fifth Second</td>
<td>15</td>
<td>6</td>
<td>144</td>
<td>36</td>
<td>4</td>
</tr>
</tbody>
</table>

After each item number on the answer sheet, blacken the one lettered space which designates the moving object to which the item refers.

155. This could be an object falling from rest near the earth's surface.

156. This object comes to rest at the end of the fifth second.

157. This object has a variable, but always positive acceleration.

158. This object has a uniform velocity.

159. The acceleration of this object is constant, but changes in sign from negative to positive.

160. The acceleration of this object is 32 feet per second per second.

161. This object has no acceleration.

162. No force is acting on this object.

163. This object has a uniformly decreasing velocity.

164. The increasing velocity of this object is due to a uniform force.
165. Assuming that air resistance is negligible, a bullet fired from a gun at X strikes the ground at Z seven seconds later. If it were not for the earth's gravitational attraction, the projectile would reach point Y in seven seconds. What is the distance from Y to Z?
A. 112 feet.
B. 224 feet.
C. 768 feet.
D. 1568 feet.
E. Insufficient data are given to determine this distance.

166. What is the distance from X to Z?
A. 224 feet.
B. 768 feet.
C. 1082 feet.
D. 1568 feet.
E. Insufficient data are given to determine this distance.

167. The fact that the bullet reached Z in the time it would take to fall from rest at Y best illustrates
A. the law of falling bodies.
B. the law of gravitation.
C. the effect of terminal velocity.
D. the law of independence of motion.
E. none of the above laws.

168. If the bullet fell from rest at Y to Z, what velocity would it have on striking Z?
A. 49 feet per second.
B. 112 feet per second.
C. 224 feet per second.
D. 256 feet per second.
E. 400 feet per second.

169. Bullets from a .45 cal. pistol have a velocity of about 500 miles per hour. Such a bullet is fired due West from the tail of a jet plane traveling due East at 800 miles per hour. Immediately after the pistol is fired, the velocity and direction of the bullet relative to the earth's surface are
A. 500 miles per hour, West.
B. 1300 miles per hour, East.
C. 300 miles per hour, West.
D. 300 miles per hour, East.
E. 800 miles per hour, East, since the bullet never leaves the pistol.

170. A ship floats because
A. it displaces a weight of water equal to its own weight.
B. the air in the hold is buoyant.
C. the surface tension of the water prevents it from sinking.
D. water is nearly incompressible.
E. its shape corresponds to that of the flow-lines of the water.

171. If a baseball is thrown straight upward, at the very top of its flight
A. its potential energy is equal to one-half of its kinetic energy.
B. it possesses no energy.
C. its potential energy will be at a maximum while its kinetic energy will be minimum.
D. it will possess no potential energy and one-half of its kinetic energy.
E. it will possess no kinetic energy and its maximum potential energy.
After the number on the answer sheet corresponding to that preceding each of the following paired items, blacken space

A if the two things referred to tend to increase together, or to decrease together
B if one of the two things tends to increase while the other tends to decrease
C if neither of the above relationships exists

(Assume that other factors remain the same.)

172. The potential energy of a falling body.
   The kinetic energy of the same body while falling.
173. The rapidity of motion of the molecules of a gas.
   The temperature of the gas.
174. The weight of an object.
   The rate at which the object falls when dropped in a vacuum.
175. Distance through which a body has fallen in a vacuum.
   Velocity at which the same body is falling.

After the item number on the answer sheet, blacken the one lettered space indicating the term at the right to which the item most correctly refers.

176. The quantity of heat needed to melt unit mass of a substance at its melting point without change in temperature.  
   A. Convection
   B. Specific heat
   C. Heat of fusion
   D. Heat of evaporation
   E. Conduction

177. The process of heat transfer where heat energy passes through a substance from molecule to molecule.  
   A. Convection
   B. Specific heat
   C. Heat of fusion
   D. Heat of evaporation
   E. Conduction

178. The process of transferring heat which is employed in warm air heating systems.  
   A. Convection
   B. Specific heat
   C. Heat of fusion
   D. Heat of evaporation
   E. Conduction

179. The quantity of heat necessary to change the temperature of unit mass of a substance one degree in temperature.  
   A. Convection
   B. Specific heat
   C. Heat of fusion
   D. Heat of evaporation
   E. Conduction

Blacken one lettered space to designate the correct answer.

180. Suppose we have a pitcher of ice in ice-water, any part of which we may use to cool a beverage. Would 200 g. of ice or 200 g. of ice-water be more effective in cooling a beverage?
   A. Ice, because it's colder.
   B. Ice-water, because its specific heat is greater.
   C. Ice, because its specific heat is greater.
   D. Ice-water, because it's heavier.
   E. Ice, because of its heat of fusion.

181. The efficiency of an engine (steam or internal combustion) is greatest if the
   A. temperature of intake is not so high.
   B. engine is not too big.
   C. intake temperature is high and the exhaust temperature is low.
   D. fuel is highly refined.
   E. temperature of exhaust is high.

182. Regions near large bodies of water are much less subject to wide variations of temperature than inland regions, because of the
   A. low heat capacity of water.
   B. high heat capacity of water.
   C. low heat conductivity of water.
   D. high heat conductivity of water.
183. The amount of work required in stopping a pitched baseball is equal to the
A. velocity of the baseball.
B. kinetic energy of the baseball.
C. mass of the baseball times its acceleration.
D. potential energy of the baseball in the catcher’s mitt.
E. square of the velocity of the baseball.

184. In raising an object to a given height by means of an inclined plane, as compared with raising the object vertically to the same height, there is a reduction in the
A. total amount of work required.
B. amount of potential energy acquired by the object.
C. speed with which the purpose can be accomplished.
D. force required.
E. amount of energy required.

185. When the piston is pushed down in a cylinder of air as shown in the diagram what occurs is best summarized by saying that
A. the temperature of the air drops, because the air molecules more frequently collide with each other and with the walls of the cylinder thus losing energy.
B. the energy expended in pushing down the piston causes the air molecules to slow down as they are pushed together. This is an example of the conservation of energy.
C. the energy expended in pushing down the piston increases the kinetic energy of the air molecules raising their temperature and causing them to collide more frequently with each other and the cylinder walls.
D. the piston compresses the air thus increasing the pressure on the walls of the cylinder. The cylinder itself cools off because the air molecules absorb heat from it. This is an example of action and reaction being equal and opposite.
E. the air heats up and its reduction in volume causes its molecules to have greater attraction for each other. Because of this the average velocity of the air molecules is decreased.

When you have finished the test go over each of your marks again with the special pencil to make each mark solid, black and glossy. Erase all superfluous marks on the answer sheet no matter how tiny.

YOUR SCORE WILL BE REDUCED BY AN AMOUNT EQUAL TO THE NUMBER OF EXTRA MARKS ON YOUR ANSWER SHEET.

When you have finished the test turn to page 20.
The following items are not a part of the test. Both regular and TV students are asked to classify items 186-190. TV students are also asked to classify items 191-200. Your answers should express your honest convictions. Your answers will have no effect on your mark for the course.

After the number on the answer sheet which corresponds to that of each of the following statements blacken space

A if you strongly agree with the statement
B if you agree with the statement
C if you neither agree nor disagree with the statement
D if you disagree with the statement
E if you strongly disagree with the statement

All students:

186. Inventions and discoveries in the physical sciences have created problems which science cannot solve.

187. The physical science course has taught me to reason more critically than other courses I have taken.

188. Mathematics and science should receive greater emphasis than other subjects in our high schools.

189. As a result of physical science instruction I expect to have a permanent interest in science.

190. The scientific method is the best method of obtaining knowledge concerning nature.

TV students only:

191. Television instruction is better able to hold one's attention than regular classroom instruction.

192. During television instruction one is handicapped by not being able to ask questions immediately about points which are puzzling.

193. Television instruction is better organized than regular classroom instruction.

194. Television demonstrations are not as clearly visible as those in regular classroom instruction.

195. Television instruction is more interesting than regular classroom instruction.

196. In television instruction one feels that the teacher is talking directly to him rather than to a class.

197. Television instruction makes one more anxious to learn what is taught than regular classroom instruction.

198. Television instruction would be more effective if followed immediately by a discussion period with a teacher who can supplement what was said over TV.

199. In one lesson of television instruction so much material is presented that one is not able to understand it fully.

200. A repeating of key points at the end of a television lesson is very helpful.
The dissertation submitted by F. Russell Koppa has been read and approved by five members of the Department of Education.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

April 27, 1960
Date

Signature of Adviser