AN EVALUATION OF THE PHYSICAL SCIENCE 201 AND 301 PROGRAM IN MANITOBA

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An Evaluation of the Physical Science 201 and 301 Program in Manitoba.

by Garth E. Martin

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CHAPTER I

INTRODUCTION

BACKGROUND TO THE STUDY

The Royal Commission on Education, whose report was made public in 1959, stated that the dominant problem in secondary school education in Manitoba continued to be that of providing equality of opportunity to all students. This was a dual problem of providing adequate facilities for all who wished to avail themselves of a secondary education and of providing a sufficient variety of courses to meet the individual needs of an increasing school population.

The solution proposed by the committee to these problems was the implementation of School Divisions and appropriate programs of study.

The Program of Studies at that time consisted of three main courses - General, High School Leaving, and Vocational. The General Program led to entrance into a university, a teachers' college, or to professions such as Nursing and Chartered Accountancy. The High School Leaving Course was a modification of the General Course arranged locally by the principals of schools for those students who did not meet the standards required for the General Course. Alternative subjects could have been chosen in place of subjects such as English or Mathematics. The student involved in this program did not write exams; consequently standing was awarded by the school on certificiation by the inspector. This course was not used by many students, explains the Commission Report, because of its low status with pupils and employers. The Commission reported no dissatisfaction with the Vocational Course as it existed at that time. The concern of most presentations centered on the academic portion of the curriculum.[1]

> "A careful study of the representations made to the Commission concerning the secondary curriculum revealed a general demand for four specific courses: Matriculation, General (non-matriculation), Vocational, and Terminal. Establishment of these four courses would result in two significant changes. The first change is the division of the present General Course into two courses: one preparing for university entrance, the other for high school graduation."

The General Course was to be divided into a Matriculation Course, identical to the old General Course, and a new General Course which was to be:

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[1] Report of the Manitoba Royal Commission on Education (Winnipeg: The Queen's Printer, 1959), p. 142.

> "A second course, substantially academic in type, with suitable non-academic options, partly identical with the first course in content, yet partly different also in aims and emphasis."[2]

The Report of the Department of Education for 1962 shows that extensive preparation preceeded the piloting of the grade ten General Course in the fall of 1962. Twenty-seven school divisions were chosen to pilot thirty-one grade ten classes. Preparation by the Department of Education included the development of a program of studies with separate detailed outlines, briefing sessions with teachers and regional meetings with teachers and administrators. The briefings and regional meetings were held principally to familiarize teachers and administrators with the background and philosophy of the new program. The Manitoba Teachers' Society held meetings at the same time to acquaint teachers not involved with the general course and to familiarize parents with the new course. A large number of meetings were held during the year to give information to people involved with or concerned about the public school system, and to administrators in post-secondary institutions.

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[2] Ibid. P. 142. Part of a brief presented by the Senate of the University of Manitoba.

> "The Grade ten outlines and texts in English, Science, and Social Studies were used during the year in two classes each and the response of the pupils and teachers was very encouraging. Interest generally was good, the pupils worked well, and consequently, achievement was very satisfactory."[3]

The preceeding statement indicates there was some course evaluation. The evaluation technique appears to have been interviews with teachers involved with the new courses to determine their viewpoints about the program and to determine how they perceived their students' reception of the program. However, evaluation at this point seems to have been incidental and not considered part of the course development.

Published material, other than the Manitoba Department of Youth and Education Annual Report, indicating the development of the physical science program is non-existent. Consequently, information needed to determine the most recent developments was obtained by interview with W. Soprovich, Coordinator of Science Curriculum in the Manitoba Department of Youth and Education.

The most comprehensive change in the physical science program began with the institution of <u>Interaction</u>

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[3] <u>The Report of the Department of Education</u> (Winnipeg: The Queen's Printer, 1962), p. 43.

of Matter and Energy in grade ten and the establishing of a physical science committee whose responsibility would be to develop a new 201 and 301 Physical Science program for Manitoba schools. The committee members were M. Spector (Chairman), C. Anthony, J. Kozak, B. Forman, F. Martens, K. Slentz and B. Unruh. The objective of the committee was to develop a program for students which would allow them to appreciate the scientific enterprise and to relate it to their daily lives. This was to be accomplished by studying basic concepts and their inter-relationships in the sciences and other disciplines.

Fifteen units were established for the Physical Science Program:

1. Organization of knowledge
2. Earth and the heavens
3. Measurement
4. Data graphs and functions
5. Periodic table and bonding
6. Quantitiative relationships
7. Heat and energy
8. Waves and wave phenomena
9. Mechanics
10. Chemical kinetics
11. Catalysts in living systems or the delicate balance: An environmental module

12. Electrochemistry
13. Electricity
14. Energy in Canada
15. Optional topics

A comprehensive introduction to the program was developed as an attempt to have the instructor develop his own philosophy of science teaching. The introduction also illustrates four different teaching methods an instructor may employ in the program.

There is an attempt to have the teacher and students stop relying on a single text for their information by using a multi-text design. Primary, secondary and teacher references are given. Class sets of 15 books are suggested for the primary references.

Each unit of work in the outline begins with an overview of the unit. The work is organized to include instructional objectives, concepts and understanding associated with the objectives and the development which promotes the understanding of the instructional objectives.

STATEMENT OF THE PROBLEM

The purpose of this investigation is to evaluate the new 201 and 301 Physical Science Programs in Manitoba.

It is imperative that the evaluation criteria be immediately and clearly stated since there are many techniques that may be used to evaluate any one program. A review of research on curriculum evaluation helped establish the criteria for the evaluation of this program. The evaluator decided the Physical Science 201 and 301 programs may be considered to have achieved their objectives if the following criteria are met:

1. The instructional objectives stated in the Physical Science program outline fulfill the general goals and philosophy of the committee which developed the program.

2. A stated percentage of students are able to successfully complete the instructional objectives stated in the course outline for each unit.

3. The attitude of the students toward the program of study is favorable.

4. The attitude of the teachers toward the program of studies is favorable.

5. Student achievement of the instructional objectives has no relation to the sex of the student and to his location in either a rural or urban school.

A study of this type cannot investigate all the criteria which indicate program success. This study will attempt to give an indication of the success of the new Physical Science 201 and 301 programs by investigating the stated criteria. Hopefully, enough interest will be generated for further research into terminal programs in all subject areas.

QUESTIONS STUDIED

The following questions and subsidiary questions have been developed from the criteria for program success.

Question 1

How well do the instructional objectives stated in the Physical Science program outline represent the philosophy of the 201 and 301 Physical Science courses?

Question 2

What is the distribution of cognitive levels as illustrated in the "Description of Instruments", for the instructional objectives stated in the Physical Science program outline?

Question 3

To what degree are students achieving the instructional objectives stated in the Physical Science program outline?

Question 4

Does the sex of the students or their location in rural or urban schools have any relation to their achievement test scores?

Question 5

What are teacher and student attitudes toward the Physical Science program?

Sub-Question 5a:-What are the attitudes of the Physical Science 201 students toward the Physical Science program as measured by the semantic differential on the concepts "What I Learned In This Science Course" and "How I Feel About This Science Course"?

Sub-Qustion 5b:-What are the attitudes of the Physical Science 301 students toward the Physical Science program as measured by the semantic differential on the concepts "What I Learned In This Science Course" and "How I Feel About This Science Course"?

Sub-Question 5c:-What are the attitudes of the Physical Science teachers toward the Physical Science program as measured by the semantic differential on the concepts "What I Taught In This Science Course" and "How I Feel About This Science Course"?

Sub-Question 5d:-What are the attitudes of the male and female Physical Science 201 and 301 students as measured by the semantic differential on the concepts "What I Learned In This Science Coruse" and "How I Feel About This Science Course"?

Question 6

What are the attitudes of Physical Science 201 and 301 students toward science students and science teachers?

Question 7

Does the Physical Science student associate what he learned in the Physical Science course or does he associate his science teacher more closely with how he feels about the Physical Science program?

STATEMENT OF SIGNIFICANCE

Evaluation is an essential part of the human experience; it takes place within all frames of reference in which individuals find themselves. This alone would be reason enough for curriculum evaluation to take place. However, the emphasis that has been placed on the necessity for education "to meet the social and economic as well as intellectual needs of society"[4] makes curriculum evaluation mandatory. The increased responsibility placed

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[4] D. Stufflebeam, "Evaluation as Enlightenment for Decision Making," Improving Educational Assessment and an Inventory of Measures of Affective Behavior, ed. Walcott H. Beatty (Washington: Association for Supervision and Curriculum Development, N.E.A., 1971), p. 42.

on the educational system has been met with program objectives of increased sophistication and complexity. It is the purpose of program evaluation to determine if these objectives are being fulfilled.

Public accountability has become part of the educational framework in our society. Education expenditures constitute a major portion of provincial and federal budgets; consequently the tax-paying public requests and deserves to know if predicted results are actually occurring. Curriculum evaluation can form part of the educational barometer from which judgements may be made.

There has recently been a proliferation of programs for teaching science in Canadian schools. Administrators will be relying more and more on curriculum evaluation to determine whether or not a particular program suits their purposes. This is particularly true when a program is accompanied by a written and laboratory package which would necessitate a large financial outlay.

When a particular program has been adopted by a province, region, or division, further research is needed to provide for program modification if it is needed. Some form of curriculum evaluation should be occurring at the division level, as there has been an increase of local autonomy in education. This would provide a sound base for the unique characteristics of the local environment to be utilized as part of the educational program.

Evaluation of the Physical Science 201 and 301 programs is significant for educators at all levels of responsibility for a variety of reasons.

This investigation attempts to coordinate several different measurements into a comprehensive evaluation of the program. Cognitive measurement of the students is achieved through the use of achievement tests. Affective measurement of students and teachers is achieved through the use of a semantic differential. The objectives stated in the course outline are categorized in order to determine whether they satisfy the philosophy of the program. The objectives are also categorized on the basis of cognitive level to determine whether they cluster in one level.

The research performed should be instrumental in developing program changes in the Physical Science 201 and 301 programs if they are required.

The semantic differential technique used to measure student and teacher attitudes toward the Physical Science 201 and 301 programs will be a readily available attitude measuring device for any science program.

The research will provide teachers with a set of unit tests in Physical Science 301 which were not previously available. Mean scores and standard deviations may be obtained for each unit test.

ASSUMPTIONS

A number of assumptions had to be made with regard to the students, instruments and program of studies being used.

1. The students answered the questions on the achievement and attitude tests to the best of their ability.

2. The students in all the schools had similar science backgrounds to the extent that they had studied either IPS or IME science in Grade Ten.

3. The difference in time at which the achievement and attitude tests were written did not affect their scores.

4. Teachers were following the program of studies for the Physical Science 201 and 301 Course.

LIMITATIONS

The introduction to the Program of Studies indicated the science teacher has four possible methods of instruction at his disposal. A limitation to this study is the inability of the investigator to determine the method which each instructor uses in each unit of study. The classroom instructor is a very important variable when measuring student achievement and attitude and in this investigation the variable is not controlled either physically or statistically. In order to determine the actual teaching method the same observer would need to visit each teacher for each unit. This is an impossible task. An alternative method would be for each teacher to indicate his most predominant teaching method; however, the validity of such a measurement would be suspect, negating the value of any results which may appear significant.

DELIMITATIONS

For the purpose of this study the following delimiations are made:

1. Data collection will take place for one semester of a school year. There will be no data collection from schools that are not semesterized.

2. Achievement testing will be multiple choice testing only. Essays, short answers, matching and true and false questions are not included in the study.

3. For the purpose of this study urban students are the ones attending school in Winnipeg. Rural students are those attending school in towns with a population of 5000 people or less.

DEFINITION OF TERMS

The concept of curriculum evaluation had to be operationally defined if it was to be meaningfully employed in this investigation.

Recent curricular evaluation innovations have expanded the concept considerably. Previously, curriculum evaluation was perceived in a restrictive paradigm. For example Harris defined evaluation as "the systematic attempt to gather evidence regarding changes in student behavior that accompany planned educational experiences."[5] Curriculum evaluation was completely student and product oriented.

Scriven, Stake and Stufflebeam were responsible for expanding the concept of evaluation to the extent that judgement by the evaluator became an important part of the whole process. Welch defines evaluation as "a gathering of information for the purpose of making decisions."[6] This very general statement expands the concept of evaluation to include judgement and values by

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[5] I. Westbury, "Curriculum Evlauation," Review of Educational Research, Vol. 40, No. 3 (1970), p. 245.

[6] W. Welch, "Curriculum Evaluation," Review of Educational Research, Vol. 39, No. 4 (1969), p. 429.

the evaluator.

This study will make use of the concept of evaluation by Scriven, Stake and Stufflebeam.

A number of concepts associated with curriculum evaluation need to be understood before such an evaluation can take place.

Scriven[7] identifies two strategies for evaluation. They are the goals and roles of evaluation and, he insists, they must not be confused.

The goals of evaluation are summarized by Ahmann as "attempts to answer certain types of questions with regard to educational instruments. Commonly, these questions concern the degree to which one instrument performs better than another, or how well the instrument performs with regard to specified criteria."[8]

The roles of evaluation described by Scriven are called uses or functions of evaluation by others. The most common roles include curriculum development or im-

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[7]Michael Scriven, "The Methodology of Evaluation," Perspectives of Curriculum Evaluation, ed. B. Othanel Smith, AERA Monograph Series #1 (Chicago: Rand McNally and Co., 1967), p. 39.

[8]Stanley Ahmann, "Aspects of Curriculum Evaluation: A Synopsis," Perspectives of Curriculum Evaluation, ed. B. Othanel Smith, AERA Monograph Series #1 (Chicago: Rand McNally and Co., 1967), pp. 86-87.

provement, teacher improvement, and student development. Cronbach[9] believes another use would be for administrative regulation. Cooke and Duncan[10] list a number of functions, many of which overlap the one already mentioned. However, several functions not stated were the identifying of boomerang or dysfunctional program consequences, an indication of the degree of transferability of programs to other georgraphic and socioeconomic surroundings, the provision of public accountability and a need to enhance the involvement and motivation of all personnel participating in a program.

Four types of curriculum evaluation have been described by Harlen:[11]

1. On going evaluation carried out as part of curriculum development.

2. Terminal evaluation performed to determine if the final product, as a whole, achieves what it set out to do.

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[9]L. Cronbach, "Course Improvement Through Evaluation," Teachers' College Record, Vol. 64, No. 8 (1963), p. 673.

[10]Robert Cooke and Robert Duncan, Evaluative Research as a Component in Orgainizational Change Strategies, Educational Resources Information Center, ERIC Document ED 064 344, U. S., April, 1972.

[11]Wynne Harlen, "Some Practical Points in Favor of Curriculum Evaluation," Journal of Curriculum Studies, Vol. 3, No. 2 (1971), p. 128.

3. Evaluation to determine the suitability of the objectives of an educational program.

4. Evaluation of the effectiveness of the educational instrument.

Scriven[12] calls the first two types of evaluation formative and summative respectively. All curricular evaluation, he states, falls into these two categories. Scriven calls the last two types described above intrinsic and pay-off evaluation respectively; these two types, he explains, may be used together effectively in both formative and summative evaluation.

All four types of evaluation, Harlen[13] states, involve the same basic activities carried out in the following order:

1. Clarify the objectives and analyse them to the point of expressing them in behavioral terms.

2. Develop and use appropriate ways of gathering evidence of behavior changes and other relevant observations or opinions.

3. Gather all relevant information and arrive at some interpretation of evidence.

4. Use the result to guide the revision of trial material and the future development of the project.

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[12] Scriven, op. cit., p. 40-45.

[13] Harlen, op. cit., p. 128.

The first step had been completed before research began on the Physical Science 201 and 301 program.

The general problem has been described as an evaluation of the Physical Science 201 and 301 program in Manitoba. There has been a subsequent breakdown of the general problem into criteria for evaluation, questions for discussion and hypotheses for testing. A literature review will subsequently justify the choice of criteria and instruments for evaluation.

CHAPTER II

LITERATURE REVIEW

A RATIONALE FOR THE CRITERIA

This evaluation of the Physical Science 201 and 301 programs does not utilize a comparison of instructional methods or curricula; and it does not make use of a control group.

L. Cronbach states[14] "the aim to compare one course with another should not dominate plans for evaluation". He continues by stating:[15]

> In an educational experiment, it is difficult to keep pupils unaware that they are an experimental group. And it is quite impossible to neutralize the biases of the teacher... It is thus never certain whether any observed advantage is attributable to the educational innovation as such, or to the greater energy that teachers and students put forth when a method is fresh and "experimental".

David Fox[16] states "since evaluation is tied to a criterion measure, the evaluation survey can be conducted with only one group and need not have any group-

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[14] L. Cronbach, _op_. _cit_., p. 676.

[15] _Ibid_.

[16] David Fox, _The Research Process in Education_, (Toronto: Holt, Rinehart and Winston, Inc., 1969) p. 434.

to-group comparison at all."

This evaluation is performed using criterial standards developed by the evaluator. The criterial standards were seen as necessary goals of the program; program success was determined by the degree to which these standards were achieved. The criteria were also chosen on the basis of the experience, time and money available to the investigator.

The criteria chosen are the result of the influence of a number of evaluation models developed over the past three decades.

Tyler[17] was largely responsible for the concept of judging performance against goals. The goals were expressed in terms of behavioral objectives and evaluation was performed on the basis of the degree to which the behavioral objectives were achieved.

Attitudes are part of the evaluation criteria. Welch[18] states "evaluation seems to demand greater attention to attitudes, opinions and values. It is often concerned with providing information on the worth of a pro-

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[17] R. Tyler, "General Statements on Evaluation," Journal of Educational Research, Vol. 35 (March 1942), pp. 492-501.

[18] W. Welch, "The Process of Evaluation," Journal of Research in Science Teaching, Vol. 11, No. 3 (1974), p. 179.

gram and here the collective judgement of people is important." Students and teachers are most closely associated with the Physical Science 201 and 301 programs, consequently their attitudes are important criterial standards.

Scriven, Stake and Stufflebeam were responsible for expanding the concept of curriculum evaluation to include value judegements by the investigator. Modern evaluation technique utilizes investigator judgement of the objectives, philosophy and outcomes of a program. Judgement ranges from a superficial survey to an evaluation based completely on investigator judgement. An example of the latter condition is Stake's[19] evaluation model.

In summary, the investigation will utilize criterial variables consisting of student achievement of objectives, attitude of students and teachers and investigator judgement of the philosophy and objectives of the program.

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[19]R. Stake, "The Countenance of Educational Evaluation," Readings in Curriculum Evaluation, eds. P. Taylor and D. Cowley (Dubuque, Iowa: Wm. C. Brown Co., 1972), pp. 95-102.

ACHIEVEMENT TESTING

Cognitive achievement of instructional objectives can be determined through achievement testing. Achievement testing has been a traditional method for program evaluation. Taylor and Cowley[20] state that program evaluation in the past was equated almost exclusively with the administration of standardized tests accompanied by a comparison of two groups or a target group and a set of norms.

Program evaluation has developed to the point where achievement testing is no longer standardized. Stake[21] indicates that standardized achievement tests are inadequate for curriculum evaluation as they are "unlikely to encompass the scope or penetrate to the depth of a particular curriculum being developed".

Project developed achievement testing provides an alternative to standardized achievement testing.

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[20] P. Taylor and D. Cowley, "New Dimensions of Evaluation," Readings in Curriculum Evaluation, eds. Taylor and Cowley (Dubuque, Iowa: Wm. C. Brown Co.), p. 1.

[21] R. Stake, "Toward a Technology for the Evaluation of Educational Programs," Perspectives of Curriculum Evaluation, ed. B. Othanel Smith (Chicago: Rand McNally and Co., 1968), p. 6.

Achievement testing can be based on instructional objectives with project developed tests, permitting an evaluator to make an assessment of a program on the basis of the achievement of instructional objectives. Welch[22] reports that of 46 evaluation projects in operation in 1969, 20 used project developed achievement testing.

An example of project developed achievement testing was reported by Butt and Wideen[23] who described an evaluation study performed on Division III Science in Saskatchewan. The program had objectives stated in behavioral terms. Butt and Wideen then developed a bank of tests to check the achievement of the program objectives.

ATTITUDES

Cronbach stated "attitudes are prominent among the outcomes with which course developers are concerned." Program evaluators must then attempt to measure these attitudes and relate them to the program as a whole.

Attitude measurement is performed using a number

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[22]Welch, loc. cit.

[23]R. Butt and M. Wideen, "Division II Science: Some Initial Findings of an Evaluation Study," Saskatchewan Journal of Education Research and Development, Vol. 3, No. 2 (1973), pp. 4-13.

of methods with the questionnaire being the most suitable for large groups. Thurstone and Likert scales have been commonly used; however, they are difficult to construct if a new instrument is desired for a particular program evaluation.

The publication of the book The Measurement of Meaning[24] provided an important new tool, described as a semantic differential, for both educational and psychological research. Osgood, one of the authors, has become so closely associated with the measurement that an index to journals insisted on listing all references to the semantic differential under his name.

Osgood and his associates were concerned with the measurement of meaning. The semantic differential was first used to measure the connotative meaning of concepts. A second and more pertinent use for this discussion, was its ability to measure attitudes toward any concept.

The semantic differential consists of a number of bipolar adjective pairs separated by a seven point space. A number of such pairs may be placed with a given concept, and a subject is asked to rate each set of ad-

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[24] C. Osgood, and others, The Measurement of Meaning, (Urbana: University of Illinois Press, 1957), p. 346.

jectives in relation to the concept.

Example: Father

Happy	___:___:___:___:___:___:___	Sad
Hard	___:___:___:___:___:___:___	Soft
Slow	___:___:___:___:___:___:___	Fast
	1 2 3 4 5 6 7	

"Father" refers in this case to the concept about which an attitude is being measured. Happy-sad, hard-soft and slow-fast are the bipolar adjective pairs. The subject would be asked to check the space which would most closely fit the feeling they had toward their father. A check in the fourth space would indicate a neutral attitude or that the adjectives did not apply to the concept.

Osgood discovered three main factors associated with the semantic differential: evaluation, potency and activity. In the example cited above the happy-sad adjectives would be evaluative measures; the hard-soft adjectives would be potency measures; the slow-fast adjectives would be activity measures. Osgood[25] suggests using bipolar adjectives with high evaluative loadings and

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[25] Ibid. p. 191.

negligible loadings on potency and activity for attitude measurement. Butzow[26] suggests that "the affective domain may be made up of several components consisting of evaluation, potency and activity." He thus develops a Science Interest Test in which the scale consists of three bipolar adjectives - one for each factor.

Example: For me, work in the area of control of plant destroying insects is:

Important ___:___:___:___:___:___:___ Trivial

Potent ___:___:___:___:___:___:___ Impotent

Active ___:___:___:___:___:___:___ Passive

McCallon and Brown[27] developed a mathematics attitude scale with both evaluative and potency factors. The semantic differential was compared to a Likert-type Mathematics Attitude Scale. There was a high correlation with both the evaluative and potency factors and the Mathematics Attitude Scale. On the basis of these stud-

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[26] J. Butzow, "A Semantic Differential Science Interest Test," School Science and Mathematics, Vol. 74, No. 3 (1974), pp. 189-196.

[27] E. McCallon and J. Brown, "Semantic Differential Instrument for Measuring Attitude Toward Mathematics: Mathematics Attitude Scale," Journal of Experimental Education, Vol. 39, No. 4 (1971), pp. 69-72.

ies it does not seem to matter whether just the evaluative factor or more factors are included in the attitude measurement.

Osgood supplies a rationale for the semantic differential's ability to map attitudes.[28] He utilizes the standard definitions of attitude to develop the concept of a "basic bipolar continuum with a neutral or zero reference point, implying that they [attitudes] have both direction and intensity." The idea that attitudes are bipolar in nature, vary in intensity, and mediate evaluative behavior suggests they are the mediational activity that operates between stimulus and response. If this is true, a factor analysis of meaning would provide a basis for determining the attitudinal component of meaning. Throughout Osgood's work, the most common factor is the evaluative aspect of meaning. He concludes then, that attitude should be identified with the evaluative dimension of the total semantic space. Osgood previously defined the meaning of a concept in terms of its locating a point in the multidimensional semantic space. Attitudes toward a concept is then defined as placing this point onto the evaluative dimension of that space.

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[28]C. Osgood, op. cit., pp. 189-191.

Osgood originally postulated the semantic space as[29] "a region of some unknown dimensionality and Euclidian in nature." As stated previously the semantic space was discovered by factor analysis to consist mainly of evaluative, potency and activity factors. These however, do not exhaust all the dimensions. Some less obvious factors were stability, tautness, novelty and receptivity.[30] Consequently, the semantic space must be considered multidimensional.

The selection of bipolar adjective scales is extremely important in view of the fact they are responsible for the mapping of the dimensions of the semantic space. Maguire[31] makes several suggestions about the selection of the scales:

1. The scales must be representative of the attitudes in the domain. The domain refers to the frame of reference in which attitudes exist. For example in measuring attitudes of students toward school, the domain would be the school. The scales must be carefully made to cover this domain or attitudinal space.

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[29] C. Osgood, _op. cit._, p. 25.

[30] C. Osgood, _op. cit._, p. 74.

[31] T. Maguire, "Semantic Differential Methodology for the Structuring of Attitudes," _American Education Research Journal_, Vol. 10, No. 4 (1973), pp. 295-306.

2. The scales must be well defined for the population of interest. The scales must relate to the subjects being tested. Elementary children could not handle bipolar adjectives such as impulsive-deliberate.

3. The scales must be appropriate to the concepts in the domain. There should not be a concept such as car with scales that are only involved with the evaluative dimension.

4. The scales must be polar opposites. Unless this is carefully observed it is possible to find a concept that could relate to both extremes on a scale. For example, a scale with fair-cruel as the extremes could be checked on both ends of a concept such as teacher.

Maguire continues by suggesting four sources for developing scales. One method is to ask people who are knowledgeable in the area of study to list adjectives that describe concepts selected from the area. Two problems associated with this method are the excessive number of evaluative scales that result and the difficulty some people have with developing adjectives useful in describing the concept.

A second method is to search relevant literature for descriptive words and phrases. Two other methods are to search related semantic differential studies and to search Roget's Thesaurus for bipolar adjectives.

Concepts selected should be able to elicit a number of responses from the subject and should relate to the domain of interest. The concepts are usually easier to develop since they represent the major attitudinal areas the investigator wishes to map. There is one consideration that must be made with regard to concepts - time. Each concept may have up to twenty scales which means five concepts would require the subjects to make 100 judgements. This is probably near the maximum number that secondary school students could be expected to make.

Osgood[32] evaluated the semantic differential as a measure of attitude by checking its reliability and validity. Reliability was determined by using six concepts and six scales on 135 subjects. The test-retest coefficients ranged from .87 to .93 with a mean of .91 when the test was readministered after five weeks.[33]

Validity was a more difficult evaluation to make; however, the semantic differential was able to discriminate, at face value, between high and low ethnocentrics and shades of voting patterns. The most conclusive test was a check against the Thurstone and Guttman scales.

The Thurstone scales and the semantic differential

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[32]C. Osgood, op. cit., p. 192.

[33]Reliability is achieved in attitude surveys when a test-retest correlation coefficient exceeds .70.

were both used to measure attitude toward the concepts of The Church, The Negro, and Capital Punishment. Two groups of subjects were used; one group received the semantic differential first and the Thurstone scale an hour later and the second group had the test in the reverse order. Two weeks later the same groups received the tests in reverse. This allowed product-moment correlation between the semantic differential and the Thurstone scales; also test-retest reliability coefficients for both tests was determined. The correlation between the sementic differential and the Thurstone scales was significantly greater than chance ($p < .01$) in each of the concepts. The reliability coefficients were extremely high and nearly equal in both cases.

A 14-item Guttman type scale with a reproducibility coefficient of .92 was developed to assess the attitudes of farmers toward the agricultural practice of crop rotation. This scale was compared to a semantic differential measuring concepts in agriculture, one of which was crop rotation. The rank order correlation between the two was significant ($r = .78$; $p < .01$).

A number of semantic differential's have been developed for various attitude measurements. While none can be used directly for this study, they do give valuable information about the construction and testing of the semantic differential for this particular study.

Butzow[34] describes the total affective domain as consisting of all three main factors in the semantic space - evaluation, potency and activity.

McCallon and Brown[35] used 15 bipolar adjective pairs in a study on attitudes toward mathematics. The mean and standard deviation on each scale was determined. A factor analysis was performed and potency and evaluative factors identified. Using the Mathematics Attitude Scale as a determinant of favorable or unfavorable attitude, the mean values of each group on the semantic differential were developed and the difference found. This allowed the detection of bipolar adjectives best suited to identifying favorable and unfavorable attitudes.

Brinton[36] went one step farther and used the separation of favorable-unfavorable groups to establish a difference in means which in turn is used to develop a Guttman type or unidimensional scale with high reproduc-

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[34] J. Butzow, _op_. _cit_., p. 189.

[35] E. McCallon and J. Brown, _op_. _cit_., p. 70-71.

[36] J. Brinton, "Deriving an Attitude Scale from Semantic Differential Data," _Semantic Differential Technique_ (Chicago: Aldine Publishing Company, 1969), pp. 467-473.

ibility and scalability. Brinton claimed this method should be able to order individuals on a given dimension. Brinton agreed with Osgood's claim of validity for the semantic differential based on high correlations with the Thurstone, Likert and Guttman scales. He used a simpler method of determining the over-all attitude of a test group on a given concept. He placed the two extreme attitudes on opposite sides of a seven space scale. The subjects were asked to check the most appropriate space. It was used to determine favorable and unfavorable attitudes.

Example: How would you rate your over-all feeling about capital punishment?

Strongly in favor of it ___:___:___:___:___:___:___ Strongly against it

Kitchen[37] constructed scales containing evaluative, potency and activity factors but used only the evaluative factors for his analysis.

Cassel[38] used the adjective check list by Gough

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[37]R. Kitchen, "Semantic Differential and Value Judgements of Student Teachers," Educational Research, Vol. 12, No. 2 (1970), pp. 150-153.

[38]R. Cassel, "Development of a Semantic Differential To Assess the Attitude of Secondary School and College Students," The Journal of Experimental Education, Vol. 39, No. 2 (1970), pp. 10-14.

and Heilbrun[39] as the main source of his bipolar adjective pairs.

Miller and Dale[40] have provided a good example of careful scale and concept selection.

DIFFICULTIES WITH CURRICULUM EVALUATION

Curriculum evaluation had a number of problems associated with its completion. Cronbach[41] considers comparisons of curricula a weak evaluation procedure because of differing treatments in different courses. He also considers test scores to be less important than item data. Test scores can be either encouraging or depressing but tell little about how to improve a course.

Cooke and Duncan[42] state a number of problems which are unique to educational evaluation:

1. There is a tendency to avoid evaluation because of ambiguities surrounding the evaluation process.

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[39] H. Gough and A. Heilbrun, The Adjective Check List Manual (California: Consulting Psychological Press, 1965).

[40] P. Miller and R. Dale, "A Semantic Differential Study of Certain Attitudes Toward University of Students from Co-Educational and Single Sex Schools," Educational Review, Vol. 25, No. 2 (1913), pp. 81-90.

[41] L. Cronbach, op. cit., p. 680.

[42] Cooke and Duncan, op. cit., pp. 11-15.

2. It is difficult to select valid criteria.

3. Inherent inflexibility of the experimental design may prevent any adjectment to measure a change in educational objectives.

4. "There is a general lack of common basic framework in educational programs which diminishes the generation of comparable data."

5. "The assumption that groups are randomly assigned to treatment and control conditions is usually not attainable in education action-research programs. As such, the internal validity of the evaluation is limited and generalizability is also threatened."

SUMMARY

In summary, this study made use of mediated evaluation employing both intrinsic and pay-off evaluation.

Multiple-choice achievement testing was used to determine student achievement of program objectives. The achievement tests were designed specifically for the objectives of the Physical Science 201 and 301 programs.

Attitude surveys were performed using the semantic differential. The instrument was project developed by the investigator.

In view of the fact the Physical Science program was in progress at the time the evaluation took place, the technique employed was primarily summative evaluation.

CHAPTER III

EXPERIMENTAL DESIGN

POPULATION AND SAMPLE

The population in this study consisted of all students taking the 201 or 301 Physical Science Program in Manitoba. The sample was divided into rural-urban students and into male-female students. A student attending a school in a town with a population less than five thousand is considered rural for the purpose of this study; a student attending a school in Winnipeg is considered urban. The number of students in each category is shown in table A.

TABLE A

	Urban		Rural	
	201	301	201	301
Male	28	47	18	29
Female	9	13	14	11

The sampling procedure was dictated by the length of time required to establish the evaluation technique. The number of students available for testing was limited to those on semesterized timetables and further, to those taking either the 201 or 301 Physical Science Program during the second semester.

The restrictions on the sample created difficulty with the external validity of the evaluation. As full term and first semester students are not being tested, generalizing the results to all students in the 201 and 301 Physical Science Program may be suspect.

The internal validity of the evaluation may also be affected by the use of only second semester students. It is possible that all students studying 201 or 301 Physical Science in a school, because of timetabling, may come from one academic or vocational area. These students may not give results indicative of the performance of all the students taking either 201 or 301 Physical Science in the school.

VARIABLES USED IN THE STUDY

Independent Variables

The independent variables used in the study were sex, location, achievement test unit and semantic differential concept. Sex and location are *ex post facto* variables.

The sex of the student and his location in a rural or urban setting was indicated on both the achievement tests and the attitude surveys. In order that the achievement tests and attitude scores could be correlated each student had to be given a letter that was recorded on both the achievement tests and attitude surveys.

The units which have achievement tests prepared for the students include all eight units in the 201 Physical Science and the following units in 301 Physical Science: chemical kinetics, mechanics, electricity, and electrochemistry.

The attitude survey used the concepts What I Learned in This Science Course; How I Feel About This Science Course; Science Teacher; and Science Student. Each of these concepts constitutes an independent variable which may be responsible for change in the dependent variables.

Dependent Variables

One dependent variable consists of the students' achievement test scores on each unit. These scores indicate the students' achievement of the objectives outlined in the program of studies.

The second dependent variable consists of the students' and teachers' scores on each concept of the semantic differential attitude survey. These scores are an indication of how the students and teachers perceive science teachers, science students and the science program.

DESIGN OF THE STUDY

Initially the superintendent of each school division in which testing was to take place was contacted, either in person or by letter, and permission was requested to contact school principals. Secondly, once permission was granted, the principals were approached, either in person or by letter. It was determined from the principal if the school offered the program and the teacher indicated whether or not he was willing to participate in the program. A total of 33 urban schools and 54 rural schools were contacted. Of these 7 urban and 7 rural schools could participate. The letters sent to the superintendent and to the schools are included in appendices B and C.

Once the sample schools were identified, the anticipated number of students were known, and the Physical Science programs being offered were determined, a package was sent to each instructor. The contents of the package are shown in appendix D and contained the instructions and tests necessary for the evaluation.

Each package contained the achievement tests which were to be given at the end of each unit where achievement testing was applicable. Each unit test was answered on the IBM test score sheet and all the achievement tests given to any one student were answered on the same sheet. The test questions on each unit were numbered cumulatively in order to eliminate confusion as to which question on the test corresponded to which number on the answer sheet. The use of the single answer sheet for each student reduced the mailing time and costs for the teacher and school involved in the project. The answer sheets were to be returned by the end of May for analysis.

The semantic differential attitude survey was completed by both students and teachers during the first week in May. The semantic differential was accompanied by instructions to the teacher on the application of the test.

The achievement tests and attitude survey were project constructed and therefore needed reliability and validity checks. These were completed before the study began and are described under instrumentation.

DESCRIPTION OF THE INSTRUMENTS

The goals and philosophy of the 201 and 301 Physical Science Program state it should "help the individual to establish an understanding and a rapport within his environment."[43]

The introduction indicates that the science program should accomplish three things:

1. It should provide an understanding of basic concepts and their interrelationships within the sciences.
2. It should develop inquiry skills and indicate the strengths and limitations of these skills when examining contemporary problems.
3. It should provide an opportunity for students to examine the interaction of science and society within the context of a number of disciplines.

Each instructional objective was read and categorized as belonging to statement "1", "2", or "3". The number of instructional objectives in each category were totalled. This was a subjective measurement, but educators argue,[44] a necessary one in order to determine the

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[43] The Department of Youth and Education Physical Science 201 and 301 Course Outline, 1973, p. 2.

[44] G. Glass, "Two Generations of Evaluation Models," Readings in Curriculum Evaluation, eds. Taylor and Cowley (Iowa: W. Brown Co., 1972).

degree to which the philosophy and goals are being achieved. The three goals stated above are not disjoint consequently each instructional objective may belong to more than one goal.

Scriven[45] develops a group of manifestation dimensions of criteria variables which are:

1. knowledge
2. comprehension
3. attitudes
4. nonmental abilities

Each instructional objective was placed in either the knowledge category (#1) or the comprehension category (#2).

The manifestation of knowledge requires objectives which ask for a display of recital skills, discrimination skills, completion skills, and labelling skills. Comprehension requires analyzing skills, synthesizing skill, evaluation skills, and problem-solving skills.

The total number of instructional objectives in each category indicated whether the program demanded knowledge or comprehension from the student.

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[45] Scriven, op. cit., pp. 75-76.

The operational dimensions of the criterion variables were measured using unit achievement tests. The unit achievement tests were designed to measure student achievement of the instructional objectives. The content of the unit achievement tests was validated with respect to the objectives stated in the course outline. The validation was performed through careful preparation of the test questions to eliminate errors and ambiguities and through the use of four teachers instructing the 201 and 301 programs to determine the suitability of the questions.

Each student was asked to indicate his sex, location in urban or rural school, and grade level by checking the appropriate space on the IBM answer sheet.

The construction of the semantic differential was achieved using the following sequence. The domain to be measured was the attitude of students and teachers involved in the Physical Science Program. Concepts necessary for the measurement of the domain had to be established. The concepts were: What I Learned In This Science Course, How I Feel About This Science Course, Science Teacher, and Science Student. The first two concepts were used to determine attitude toward the program. The last two concepts permit the students to indicate how they perceive themselves and their teachers.

The bipolar adjectives are then chosen in order to satisfy the concepts. The bipolar adjective scales were drawn from a number of sources. The majority were obtained from previously constructed semantic differential scales and from Osgood's gleaning of Roget's Thesaurus. There was no attempt to construct a unidimensional scale since the affective domain contains potency and activity as well as evaluation factors; however, the scales used were all high on the evaluation factor. The bipolar adjectives chosen are the same for each concept, consequently there were several pairs of bipolar adjectives that registered neutral for each concept. The adjective pairs chosen were the following: (1) Good-Bad (2) Pleasurable-Painful (3) Meaningful-Meaningless (4) Important-Unimportant (5) Positive-Negative (6) Wise-Foolish (7) Heavy-Light (8) Colorful-Colorless (9) Complex-Simple (10) Interesting-Boring (11) Nice-Awful (12) Fair-Unfair (13) Fresh-Stale (14) Pleasing-Annoying (15) Precise-Vague.

The concepts were placed at the top of the page and the scales arranged below. Each concept was placed on a separate page as suggested by Osgood. This makes the survey easy to score and has constancy of meaning in the attitude being judged. The direction of polarity in the adjective pairs was reversed in scales (3), (5), (7), (9), (11), and (14) in order to prevent the formation of position preferences. Instructions to the students were included with the survey and were handed out to each student as part of the semantic differential. The instructions were read by the teacher and any questions by the students were answered at that time. A separate sheet of instructions was given to the instructor indicating the method to be followed in applying the attitude survey. The semantic differential, instructions to the student and instructions to the teacher are included in Appendix D.

The attitude survey was given to a representative group of students taking the Physical Science Program during the first semester. The survey was applied twice with a two week interval between writings. The same students were involved in both trials, allowing a test-retest reliability check. The results of the reliability check showed a correlation of 0.83 for the concept What I Learned in This Science Course; 0.78 for How I Feel About This Science Course; 0.70 for Science Teacher; and 0.78 for Science Student. All the correlations except Science Teacher were significant at the .001 level. The concept Science Teacher correlated at the .01 level of significance. The lower correlation between tests on the concept Science Teacher was expected as a student's attitude toward his teacher fluctuates more than his attitude toward the other three concepts.

Osgood, Aitken, and others have demonstrated the validity of the semantic differential technique for determining attitudes by correlating its results with established attitude tests. The same technique is used in this evaluation, consequently the previous validity checks should apply to the present attitude survey. In addition the high correlation coefficient in the preliminary study for each of the concepts on the test-retest reliability measure gave credence to the validity of this semantic differential.

HYPOTHESES TESTED

The following hypotheses were developed in conjunction with the questions studied:

Hypothesis 1

For the three units of the Physical Science program which were used:

Ho 1.1 There is no significant difference in achievement test scores between male and female students in the Physical Science 201 program.

Ho 1.2 There is no significant difference in achievement test scores between male and female students in the Physical Science 301 program.

Ho 1.3 There is no significant difference in achievement test scores between rural and urban students in the Physical Science 201 program.

Ho 1.4 There is no significant difference in achievement test scores between rural and urban students in the Physical Science 301 program.

Hypothesis 2

For the semantic differential given to both students and teachers:

Ho 2.1 There is no significant difference in the attitude of all the students and teachers toward the Physical Science program as measured on the concept "What I Learned In This Science Course" for students and "What I Taught In This Science Course" for teachers.

Ho 2.2 There is no significant difference in the attitude of all the students and teachers toward the Physical Science program as measured on the concept "How I Feel About This Science Course".

Ho 2.3 There is no significant difference in the attitude of male and female students toward the Physical Science 201 program as shown on the concept "How I Feel About This Science Course".

Ho 2.4 There is no significant difference in the attitude of male and female students toward the Physical Science 301 program as shown on the concept "How I Feel About This Science Course".

Hypothesis 3

For the semantic differential given to students:

Ho 3.1 There is no significant difference in the proximity of semantic space for the concepts "How I Feel About This Science Course" and "What I Learned In This Science Course" and the concepts "How I Feel About This Science Course" and "Science Teacher" for Physical Science 201 students as measured by Osgood's D statistic and the Wilcoxon signed pairs test of significance.

Ho 3.2 There is no significant difference in the proximity of semantic space for the concepts "How I Feel About This Science Course" and "What I Learned In This Science Course" and the concepts "How I Feel About This Science Course" and "Science Teacher" for Physical Science 301 students as measured by Osgood's D statistic and the Wilcoxon signed pairs test of significance.

ANALYSIS OF DATA

The hypotheses were tested using the following methods of data analysis.

Hypothesis 1 was tested using a three factor analysis of variance with repeated measures on the unit tests being used. The independent variables were sex, location and unit test; the dependent variable was achievement test scores on each test. The first three unit tests were used for the analysis as these tests were the ones which all students had completed. The analysis was performed.[46]

Hypothesis 2 was tested using the chi square test of significance and a phi coefficient test for degree of relationship between two scores. The chi square test was suggested by Osgood[47] as the best method to determine if two scores could have come from a single population, when two groups and a single concept are involved. The non-parametric test of significance was chosen as the semantic differential results do not indicate a normal distribution and some cells in the sample were small. The small sample of teachers in the cells necessitated the use of Yate's correction[48] factor which adjusts the frequency of each cell.

Hypothesis 3 was tested using the Wilcoxon signed pairs test of significance to test the sets of D statistics using the student sample. Osgood[49] states that

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[46]The computer program used was the BMDP2V Statistical package which is part of the Biomedical program available at the University of Manitoba.

[47]Osgood, op. cit., p. 100.

[48]H. Walker and J. Lev, Statistical Inference, (New York: Holt and Co., 1953), p. 106.

[49]Osgood, op. cit., p. 101.

this test is the one best suited for a test of significance between two sets of D statistics for one group.[50]

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[50]The BMDP3S statistical package used for the analysis is part of the Biomedical program available at the University of Manitoba.

CHAPTER IV

ANALYSIS OF THE DATA

INTRODUCTION

The results in this chapter are presented under each question derived from the criteria for program success. The results were derived from the use of the following tests of central tendency: analysis of variance using repeated measures and the Wilcoxon signed pairs test. A chi square test was also used to determine relationships between groups. Questions not requiring statistical analysis were accompanied by tables which reduced that data into percent or mean scores. The null hypotheses were rejected when the probability level was less than five per cent.

PRESENTATION OF THE FINDINGS

Question 1

How well do the instructional objectives stated in the Physical Science program outline represent the philosophy of the 201 and 301 physical science courses?

The philosophy of the Physical Science program was organized by the investigator into three categories as stated in the "Description of Instruments". Each instructional objective was placed in one or more of the categories if it satisfied that part of the program philosophy relating to the category.

Objectives placed in category one promoted student understanding of basic concepts and their interrelationships in the sciences. Objectives placed in category two promoted the development of student inquiry skills. Objectives placed in category three promoted the interdisciplinary aspects of the Physical Science program.

It was discovered that many objectives could be placed in more than one category.

The total per cent of time the program suggests to be spent on each unit is illustrated in tables 1 and 2 for Physical Science 201 and 301 respectively.

As stated previously, placing instructional objectives in categories of program philosophy is subjective but considered necessary in order to obtain an indication of how well the Physical Science program promoted its stated philosophy.

The frequency and per cent of objectives which satisfy each of the categories illustrating program philosophy are shown in table 1.

TABLE 1

FREQUENCY AND PER CENT OF SATISFACTION BY OBJECTIVES

FOR CATEGORIES ILLUSTRATING PROGRAM PHILOSOPHY

Physical Science 201

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Total
Recommended time on unit	5%	5%	10%	10%	20%	10%	10%	30%	100%
Frequency of objectives category 1	6	5	13	7	10	7	12	32	92
Frequency of objectives category 2	6	5	7	5	8	4	12	21	68
Frequency of objectives category 3	3	2	0	0	0	0	0	2	7
Weighted percentage of objectives in category 1	5	5	10	10	20	10	10	30	100
Weighted percentage of objectives in category 2	5	5	5	7	16	8	10	20	76
Weighted percentage of objectives in category 3	3	2	0	0	0	0	0	1	6

Physical Science 301 contains six units. Unit two has two major sections: unit 2a and unit 2b. Unit 2b has two section, one of which was to be completed by the class. Unit 2b alternative one is titled, "Catalysts in Living Organisms" and unit 2b alternative two is titled "Reaction Kinetics in Ecological Systems". Unit 2b alternative two does not contain instructional objectives as do the other units but it suggests a time of 15 per cent of the total time available to the class. Unit 6 also has no instructional objectives included in the program outline. Both Unit 2b alternative two and Unit 6 require the science class to be involved with all three categories illustrating the program philosophy.

Table 2 illustrates the frequency when applicable, and percentage of objectives which satisfy each of the categories illustrating program philosophy.

Question 2

What is the distribution of cognitive levels as illustrated in the "Description of Instruments" for the instructional objectives stated in the Physical Science program outline?

Each instructional objective in the Physical Science program outline was placed in one of two cognitive levels suggested by Scriven. The first cognitive level

TABLE 2

FREQUENCY AND PER CENT OF SATISFACTION OF OBJECTIVES
FOR CATEGORIES ILLUSTRATING PROGRAM PHILOSOPHY

Physical Science 301

	Unit 1	Unit 2a	Unit 2b alternative 1	Unit 2b alternative 2	Unit 3	Unit 4	Unit 5	Unit 6	Total alternative 1	Total alternative 2
Recommended time on Unit	30%	20%	10%	15%	10%	10%	10%	5-10%		
Frequency of objectives category 1	5	8	7	*	9	6	*	*	35	28
Frequency of objectives category 2	5	4	5	*	7	6	*	*	27	22
Frequency of objectives category 3	0	1	2	*	0	0	*	*	3	1
Weighted percentage of objectives in category 1	30	20	10	15	10	10	10	5-10	100	100
Weighted percentage of objectives in category 2	30	10	7	15	8	10	10	5-10	85	88
Weighted percentage of objectives in category 3	0	3	3	15	0	0	10	5-10	26	33

*Objectives not stated

was called the knowledge level and the second cognitive level was called the comprehension level. Table three illustrates the results of the analysis for Physical Science 201 and 301.

Question 3

To what degree are students achieving the instructional objectives stated in the Physical Science program outline?

The degree of student achievement was determined through the use of objective testing. Each item on the achievement test was based on an instructional objective stated in the program outline. It was necessary that the cognitive level of the question and the corresponding instructional objective be the same. This congruence was maintained with the majority of the questions. If there was a discrepancy the cognitive level of the test question took priority over the objective in the analysis.

The cognitive level of each test question was determined. The percentage achievement for a given question indicated the degree of achievement for a given objective having a specified cognitive level.

Testing was terminated in most classes in the first part of June. At this time none of the classes

TABLE 3

NUMBER AND PER CENT OF OBJECTIVES IN EACH COGNITIVE LEVEL FOR PHYSICAL SCIENCE 201 and 301

Unit	Physical Science 201		Physical Science 301	
	Cognitive level		Cognitive level	
	1	2	1	2
	Number of Objectives:		Number of Objectives:	
1	5	1	10	10
2	5	0	7	9
3	7	6	8	2
4	4	3	15	4
5	4	6	No stated objectives	
6	4	3	No stated objectives	
7	4	8	--	--
8	20	12	--	--
Total	53	39	40	25
Per Cent	58%	42%	62%	38%

had completed the programs and a number of unit tests were incomplete. For this reason only the following unit tests were analyzed: one through four in the Physical Science 201 program, and unit tests one, two(a), three and four in the Physical Science 301 program. The percent achievement for each test item by the student sample was determined. Each test item was then classified as belonging to either cognitive level one or two. The mean per cent achievement for each cognitive level for the objectives under consideration was determined as illustrated in tables 4 and 5.

The investigator arbitrarily chose the following achievement rates as desirable:

1) cognitive level 1 should have 65% achievement
2) cognitive level 2 should have 55% achievement.

TABLE 4

PER CENT ACHIEVEMENT OF TEST QUESTIONS HAVING A COGNITIVE LEVEL OF ONE

	Cognitive level one	
	Physical Science 201	Physical Science 301
Mean Per Cent Achievement for All Units Considered	56.6%	53.4%

TABLE 5

PER CENT ACHIEVEMENT OF TEST QUESTIONS HAVING A COGNITIVE LEVEL OF TWO

	Cognitive level two	
	Physical Science 201	Physical Science 301
Mean Per Cent Achievement For All Units Considered	49.8%	44.8%

<u>Question 4</u>

Does the sex of the students or their location in rural or urban schools have any effect on their achievement test scores?

The multiple choice achievement tests were answered by students on the standard IBM score sheets. Each student was requested to indicate sex, location and grade on the answer sheet. The IBM answer sheets were corrected through the use of an answer template. The tests are shown in appendix D. The analysis utilized the first three tests as these were the only tests completed by all students.

The test results were converted to per cent scores for each student. The students' sex, location, grade, and test scores were then analyzed using a multifactor analysis of variance with repeated measures on achievement tests. The results of the analysis are illustrated in tables 6 and 7.

The cell populations, means, and standard deviations are shown in tables one and two of appendix A.

TABLE 6

FACTORIAL USING ANALYSIS OF VARIANCE
WITH REPEATED MEASURES ON TESTS
FOR PHYSICAL SCIENCE 201 STUDENTS

Source	DF	SS	MS	F	P
Sex	1	35.43	35.43	0.108	0.744
Location	1	509.62	509.62	1.55	0.218
Sex x Location	1	167.78	167.78	0.51	0.478
Tests	2	5139.11	2569.55	16.42	0.000*
Tests x Sex	2	845.74	422.87	2.70	0.072
Tests x location	2	1733.47	866.73	5.54	0.005**
Tests x sex x location	2	352.38	176.19	1.13	0.328

*p < .01
**p < .05

TABLE 7

FACTORIAL USING ANALYSIS OF VARIANCE
WITH REPEATED MEASURES ON TESTS
FOR PHYSICAL SCIENCE 301 STUDENTS

Source	DF	SS	MS	F	P
Sex	1	26.02	26.02	0.06	0.800
Location	1	2537.67	2537.67	6.27	0.014**
Sex x Location	1	39.04	39.04	0.09	0.757
Tests	2	1447.09	723.55	4.32	0.015**
Tests x sex	2	249.39	124.69	0.74	0.476
Tests x location	2	991.54	495.77	2.96	0.054
Tests x sex x location	2	294.02	147.01	0.88	0.417

*p < .01
**p < .05

Ho. 1.1 There is no significant difference in achievement test scores between male and female students in the Physical Science 201 program.

Null hypotheses Ho 1.1 was tested using the ANOVA with repeated measures on the tests used. The level of significance as shown in table 6 did not exceed the .05 probability level (p = 0.74) and the null hypothesis was not rejected. There is no evidence to suggest that the sex of the students is related to their achievement test scores in the Physical Science 201 program.

> Ho 1.2 There is no significant difference in achievement test scores between male and female students in the Physical Science 301 program.

Null hypothesis Ho 1.2 was tested using the ANOVA with repeated measures on the test used. The level of significance in table 7 did not exceed the .05 probability level (p = 0.80) and the null hypothesis was not rejected. There is no evidence to suggest that the sex of the students is related to achievement test scores in the Physical Science 301 program.

> Ho 1.3 There is no significant difference in achievement test scores between rural and urban students in the Physical Science 201 program.

Null hypothesis 161.3 was tested using the ANOVA with repeated measures on the test used. The level of significance in table 6 for location did not exceed the .05 probability level (p = 0.22) and the null hypothesis was not rejected. There is no evidence to suggest the location of the students is related to achievement test scores in the Physical Science 201 program.

> Ho 1.4 There is no significant difference in achievement test scores between rural and urban students in the Physical Science 301 program.

Null hypothesis 1.4 was tested using the ANOVA with repeated measures on the test used. The level of significance in table 7 for location exceeded the .05 probability level (p = .014) and the null hypothesis was rejected. The location of the Physical Science 301 students in rural or urban schools had a significant effect on their achievement test scores. Urban 301 students achieved significantly better than rural 301 students.

Findings Related to Question 4:-There is no evidence to suggest the interaction of the sex of the students and their location in a rural or urban school was related to achievement test scores in both grades tested.

There was a significant difference in achievement test scores for each unit tested. This was anticipated as some tests were easier than others in both grades tested.

Location was a significant factor in achievement test scores when considering its interaction with the unit tests used. Rural schools did significantly better than urban schools in some tests and the opposite occurred in other tests.

There was no evidence to suggest that location and the tests used were related for the Physical Science 301 students. The urban Physical Science 301 students answered more questions correctly to a significant degree on every test.

Question 5

What are student and teacher attitudes toward the Physical Science 201 and 301 programs?

The measurement of student and teacher attitudes was performed using a semantic differential technique. The concepts relating to student attitude toward the Physical Science program were, "What I Learned In This Science Course" and "How I Feel About This Science Course". Teacher attitudes were measured using the same concepts by substituting the word "Taught" for the word "Learned" in the first concept. The seven point scales were calibrated so that a +3 score represented a maximum positive attitude on a scale, a -3 score represented a maximum negative attitude on a scale, and zero represented a neutral attitude on a scale.

The semantic differential was analyzed using mean scores for students and teachers on each scale for both concepts as shown in tables 8 and 9.

The results of the data tables are presented in graphical form in graphs 1 and 2.

Sub-Question 5a:-What are the attitudes of the Physical Science students as measured by the semantic differential on the concepts "What I Learned In This Science Course" and "How I Feel About This Science Course"?

TABLE 8

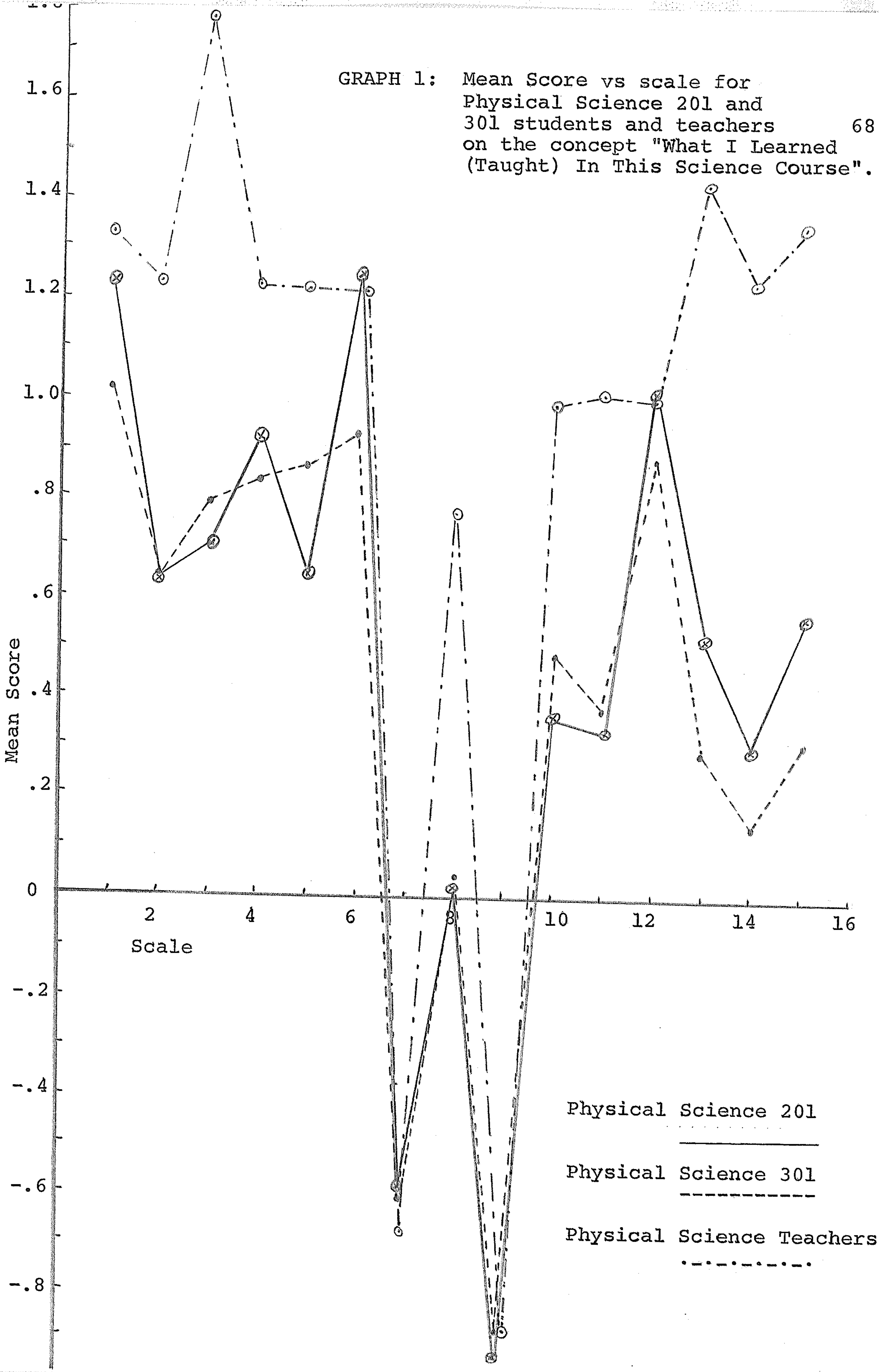
ATTITUDE TOWARD THE PHYSICAL SCIENCE PROGRAM AS SHOWN BY RAW AND MEAN SCORES ON THE CONCEPT "WHAT I LEARNED (TAUGHT) IN THIS SCIENCE COURSE" FOR PHYSICAL SCIENCE 201 AND 301 STUDENTS AND TEACHERS

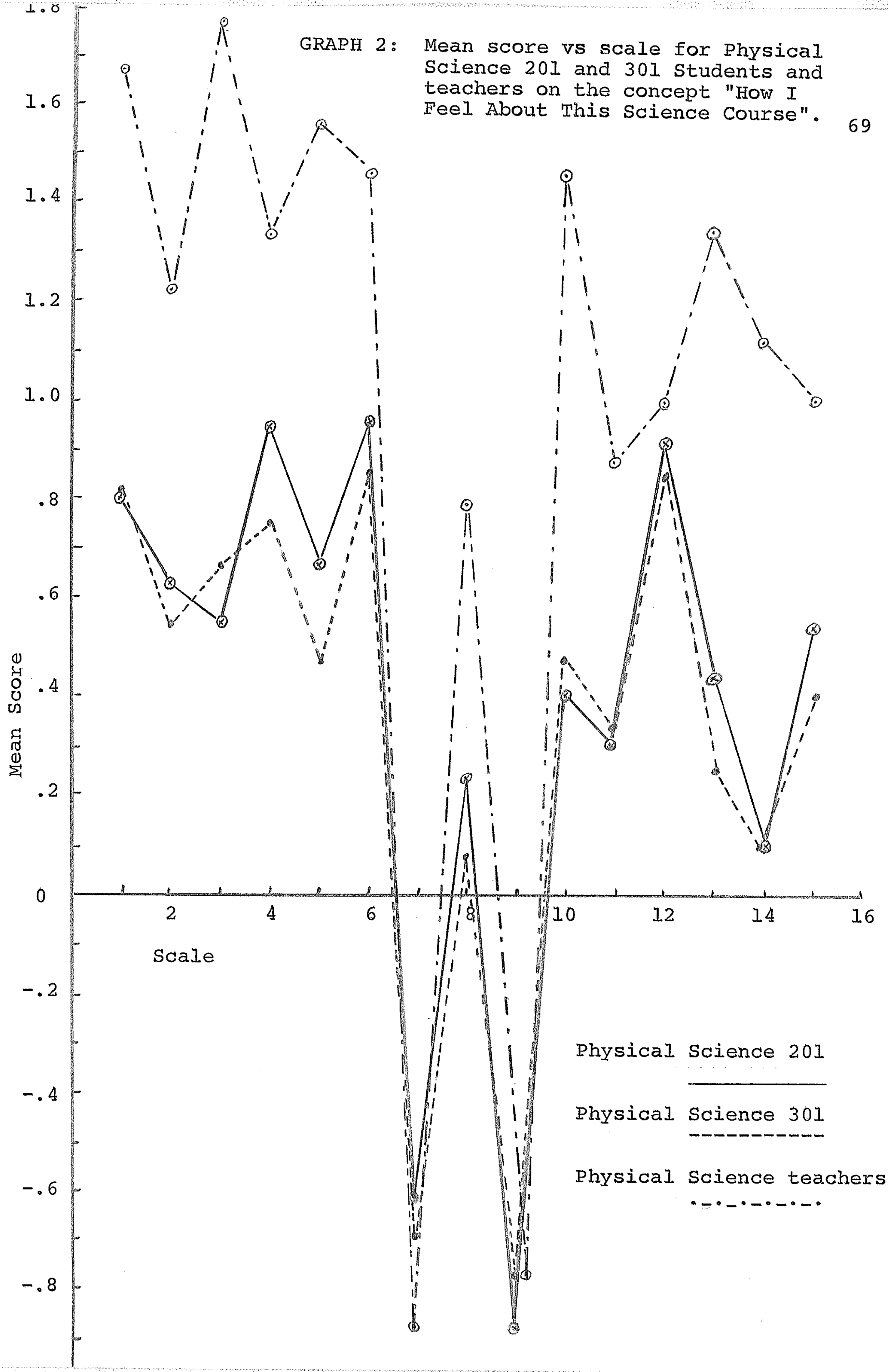
Scale number	Bipolar adjectives	201 Raw Score	201 Mean Score	301 Raw Score	301 Mean Score	201&301 Teacher Raw Score	201&301 Teacher Mean Score
1	Good-Bad	85	1.23	102	1.03	13	1.33
2	Pleasurable-Painful	44	.64	65	.66	11	1.22
3	Meaningful-Meaningless	48	.70	78	.79	16	1.78
4	Important-Unimportant	64	.93	82	.83	11	1.22
5	Positive-Negative	44	.64	85	.86	11	1.22
6	Wise-Foolish	86	1.25	92	.93	11	1.22
7	Light-Heavy	-41	-0.59	-60	-0.61	-6	-0.67
8	Colorful-Colorless	2	.03	19	.19	7	.78
9	Simple-Complex	-66	-0.96	-86	-0.87	-8	-0.89
10	Interesting-Boring	27	.39	50	.51	9	1.0
11	Nice-Awful	25	.36	39	.39	10	1.11
12	Fair-Unfair	81	1.17	86	.87	10	1.11
13	Fresh-Stale	38	.55	30	.30	13	1.44
14	Pleasing-Annoying	21	.30	14	.14	11	1.22
15	Precise-Vague	40	.58	32	.32	12	1.33
Concept Mean		33.2	.48	41.9	.42	8.73	.96
		N=69		N=99		N=9	

TABLE 9

ATTITUDE TOWARD THE PHYSICAL SCIENCE PROGRAM AS SHOWN BY RAW AND MEAN SCORES ON THE CONCEPT "HOW I FEEL ABOUT THIS SCIENCE COURSE" FOR PHYSICAL SCIENCE 201 AND 301 STUDENTS AND TEACHERS

Scale number	Bipolar adjectives	201 Raw Score	201 Mean Score	301 Raw Score	301 Mean Score	Teacher Raw Score	Teacher Mean Score
1	Good-Bad	55	.80	80	.81	15	1.67
2	Pleasurable-Painful	43	.62	55	.56	11	1.22
3	Meaningful-Meaningless	38	.55	67	.68	16	1.78
4	Important-Unimportant	66	.96	75	.76	12	1.33
5	Positive-Negative	46	.67	47	.47	14	1.56
6	Wise-Foolish	66	.96	84	.85	13	1.44
7	Light-Heavy	-42	-0.61	-69	-0.70	-8	-0.89
8	Colorful-Colorless	17	.25	8	.08	7	.78
9	Simple-Complex	-60	-0.87	-76	-0.77	-7	-0.78
10	Interesting-Boring	29	.42	49	.49	13	1.44
11	Nice-Awful	22	.31	35	.35	8	.89
12	Fair-Unfair	64	.93	85	.86	9	1.0
13	Fresh-Stale	32	.46	26	.26	12	1.33
14	Pleasing-Annoying	8	.12	12	.12	10	1.11
15	Precise-Vague	37	.54	40	.40	9	1.0
Concept Mean		28.1	.41	34.5	.35	8.9	.99
		N=69		N=99		N=9	


GRAPH 1: Mean Score vs scale for Physical Science 201 and 301 students and teachers on the concept "What I Learned (Taught) In This Science Course".
Mean Score
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
Scale
2
4
6
8
10
12
14
16
Physical Science 201
Physical Science 301
Physical Science Teachers


GRAPH 2: Mean score vs scale for Physical Science 201 and 301 Students and teachers on the concept "How I Feel About This Science Course".
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
Mean Score
2
4
6
8
10
12
14
16
Scale
Physical Science 201
Physical Science 301
Physical Science teachers

A consideration of the mean score for each concept indicates the concept "What I Learned In This Science Course" has a greater value (0.48) than the concept "How I Feel About This Science Course" (0.41 for Physical Science 201 students. Osgood states no test of significance is available to determine if the score on one concept is significantly different from the score on another for the same group. Six scales have a mean score difference greater than the mean score difference of the concepts. The good-bad scale shows the greatest difference with a scale mean score difference of 0.43 with concept 2 ("How I Feel About This Science Course) receiving the lower value. Four other scales show concept 2 having a lower mean score. The scales are meaningful-meaningless (difference = 0.15), wise-foolish (difference = 0.29), fair-unfair (difference = 0.24), and pleasing-annoying (difference = 0.18). One scale colorful-colorless showed concept 2 had a higher score (.22) than concept 1, ("What I Learned In This Science Course").

Generally, the Physical Science 201 students feel the science program itself is not as good, meaningful, wise, fair, or pleasing as what they learned from the program.

The general shape of the graph for the Physical

Science 201 students' attitude toward concepts 1 and 2 are very similar. Both concepts show that the students consider what they learned and the science program itself to be heavy and complex. The same four scales showed the highest scores for both concepts: scale 1 (good-bad), scale 4 (important-unimportant), scale 6 (wise-foolish) and scale 12 (fair-unfair).

As indicated by the scales, the students feel that what they learned and the science course itself was good, important, wise, fair, heavy and complex.

Sub-Question 5b:-What are the attitudes of the Physical Science 301 students toward the program as meas-used by the semantic differential on the concepts "What I Learned In This Science Course" and "How I Feel About This Science Course"?

The mean scores on each scale for concept 1 ("What I Learned In This Science Course") and concept 2 ("How I Feel About This Science Course") are very similar as shown by the graphs 1 and 2.

Concept 1 received a higher mean score (0.42) than concept 2 (0.35). Two scales have a mean score difference which is larger than the mean score difference on the concepts. These scales are good-bad (difference = 0.42) and positive-negative (difference = 0.39).

It appears the Physical Science 301 students feel the science program itself is not as good as or as positive as what they learned from the program.

The Physical Science 301 students indicate that both what they learned and the science course itself were heavy and complex. High scores were obtained on scale 1 (good-bad), scale 4 (important-unimportant, scale 6 (wise-foolish) and scale 12 (fair-unfair) for both concepts. These scales were the same as those for the high scores on both concepts for the Physical Science 201 students.

The scales indicate the Physical Science 301 students feel that what they learned and the science course itself was good, important, wise, fair, heavy and complex.

Sub-Question 5c:-What are the attitudes of the Physical Science teachers toward the program as measured by the semantic differential on the concepts "What I Taught In This Science Course" and "How I Feel About This Science Course."

Concept 1 ("What I Taught In This Science Course") and concept 2 ("How I Feel About This Science Course") produce similar graphs of mean scores versus scales on tables 8 and 10. The scales showing large differences are good-bad (difference = 0.34), positive-negative (difference = 0.34) interesting-boring (difference = 0.44) and precise-vague (difference = 0.33). The first three scales mentioned show higher values for concept 2 and the fourth scale shows a higher value for concept 1.

The Physical Science teachers feel the science course itself was good, positive, and interesting but not as precise as what they taught.

Physical Science teachers gave both concepts 1 and 2 a negative score on the light-heavy and simple-complex scales. All other scales except the colorful-colorless and nice-awful scales received mean scores of 1.0 or more for both concepts.

Physical Science teachers feel what they taught and the science course itself is heavy and complex as well as good, pleasurable, meaningful, important, positive, wise, interesting, nice, fair, fresh, pleasing and precise.

Ho 5.1 There is no significant difference between the attitude of teachers toward the concept "What I Taught In This Science Course" and students toward the concept "How I Feel About This Science Course".

Osgood[51] states the test of significance for two groups and one concept is the chi square median test. Walker and Lev[52] state that small entries in a conting-

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[51] Osgood, op. cit., p. 100.

[52] Walker and Lev, op. cit., p. 103.

ency table should be accompanied by a correction factor called Yates correction. The small sample of teacher attitudes necessitates the use of this correction factor.

Table 10 shows the frequency of response above and below the total sample median for each student and teacher on the concept "What I Learned (Taught) In This Science Course".

TABLE 10

CHI SQUARE MEDIAN TEST CONTINGENCY TABLE FOR THE CONCEPT "WHAT I LEARNED (TAUGHT) IN THIS SCIENCE COURSE" USING YATES CORRECTION FACTOR FOR SMALL SAMPLES

Source	Above Population Median	Below Population Median	Totals
Teachers	6	3	9
Students	83	86	169
Totals	89	89	178

phi coefficient =.05 $x_c^2 = .47$, df = 1 , $p < .05$

when $p < .05$ then $x^2 > 3.84$

A chi square value of 0.47 with df = 1 is not significant at the .05 level. The null hypothesis cannot be rejected. A phi coefficient of .05 indicates there is no reliable evidence that there is a relationship between students and teachers scores on the concept "What I Learned (Taught) In This Science Course".

> Ho 5.2 There is no significant difference in the attitude of all the students and teachers toward the Physical Science program as measured by the semantic differential on the concept "How I Feel About This Science Course".

The analysis for hypothesis 5.2 followed the same procedure as that used for hypothesis 5.1 as the samples and analysis requirements are the same. The results of the analysis are shown in table 11.

TABLE 11

CHI SQUARE MEDIAN TEST CONTINGENCY TABLE FOR THE CONCEPT "HOW I FEEL ABOUT THIS SCIENCE COURSE" USING YATES CORRECTION FACTOR FOR SMALL SAMPLES

Source	Above Population Median	Below Population Median	Totals
Teachers	8	1	9
Students	94	75	169
Totals	102	76	178

phi coefficient = .12 $x_c^2 = 2.62$, df = 1 , $p < .05$
when $p < .05$ then $x^2 > 3.84$

The chi square value of 2.62 with df = 1 is not significant at the .05 level. The null hypothesis cannot be rejected. A phi coefficient of 0.12 indicates there is no reliable evidence that there is a relationship between students and teachers scores on the concept "How I Feel About This Science Course".

Sub-Question 5d:-What are the attitudes of the male and female students in the Physical Science 201 and 301 programs?

Traditionally physical science courses have been male dominated and the Physical Science 201 and 301 programs are no exception. It is of interest to determine the attitudes of both male and female students toward the Physical Science program through their raw and mean scores on the concepts "What I Learned In This Science Course" and "How I Feel About This Science Course" as shown in tables 12 and 13.

TABLE 12

RAW AND MEAN SCORES FOR MALE AND FEMALE STUDENTS ON CONCEPTS 1 AND 2
Physical Science 201

	N	Concept 1		Concept 2	
		Raw Score	Mean	Raw Score	Mean
Male	46	26.64	0.58	21.67	0.47
Female	23	9.44	0.41	7.25	0.32

TABLE 13

RAW AND MEAN SCORES FOR MALE AND FEMALE STUDENTS ON CONCEPTS 1 AND 2

Physical Science 301

	N	Concept 1		Concept 2	
		Raw Score	Mean	Raw Score	Mean
Male	76	28.4	0.37	34.86	0.46
Female	24	15.39	0.64	13.85	0.58

The tables indicate a decrease in the proportion of female students in the Physical Science 301 program compared to the Physical Science 201 program. There is a corresponding increase in the mean score on both concepts for females compared with the males

Hypothesis 2:-Hypotheses 2.3 and 2.4 will be tested using the concept "How I Feel About This Science Course". A chi square test will be used to indicate the probability of a relationship existing and a phi coefficient will be used to indicate the degree of relationship between the males and females. Tables 14 and 15 show the results of the analysis.

Ho 2.3 There is no significant difference in the attitude of male and female students toward the Physical Science 201 program as shown on the concept "How I Feel About This Science Course".

TABLE 14

CHI SQUARE TEST CONTINGENCY TABLE FOR THE CONCEPT "HOW I FEEL ABOUT THIS SCIENCE COURSE

Physical Science 201

Source	Above Population Median	Below Population Median	Totals
Male	22	24	46
Female	11	12	23
Totals	33	36	69

phi coefficient = 0 $x^2 = 0$, df = 1, $p < .05$
when $p < .05$ then $x^2 > 3.84$

TABLE 15

CHI SQUARE TEST CONTINGENCY TABLE FOR THE CONCEPT "HOW I FEEL ABOUT THIS SCIENCE COURSE"

Physical Science 301

Source	Above Population Median	Below Population Median	Totals
Male	40	36	76
Female	14	10	24
Totals	54	46	100

phi coefficient = .05 $x^2 = .24$, df = 1, $p < .05$
when $p < .05$ then $x^2 > 3.84$

The chi square value of zero for df = 1 indicates there is no relation between the male and female students in Physical Science 201 program on the concept "How I Feel About This Science Course". The null hypothesis was not rejected and the phi coefficient of zero indicates any relationship between the two groups is purely by chance.

> Ho 2.4 There is no significant difference in the attitude of male and female students toward the Physical Science 301 program as shown on the concept "How I Feel About This Science Course".

The chi square value of 0.24 with df = 1 was not significant at the .05 probability level. The null hypothesis was not rejected. The phi coefficient of .05 indicates any relationship between the two groups on the concept is purely by chance.

Question 6

What are the attitudes of Physical Science 201 and 301 students toward science students and science teachers as measured by the semantic differential on the concept "Science Student" and Science Teacher"?

The raw scores and mean scores for both grades on each concept are illustrated in table 16.

The mean scores on the concepts "Science Student" and "Science Teacher" for the 201 and 301 students were

TABLE 16

RAW SCORES AND MEAN SCORES ON THE CONCEPTS "SCIENCE STUDENT" AND "SCIENCE TEACHER" FOR PHYSICAL SCIENCE 201 AND 301 STUDENTS

Scale Number	Bipolar Adjective	"Science Student"				"Science Teacher"			
		201 Raw Score	201 Mean Score	301 Raw Score	301 Mean Score	201 Raw Score	201 Mean Score	301 Raw Score	301 Mean Score
1	Good-Bad	66	.96	89	.89	113	1.64	113	1.13
2	Pleasurable-Painful	63	.91	111	1.11	107	1.55	98	.98
3	Meaningful-Meaningless	47	.68	73	.73	92	1.33	100	1.00
4	Important-Unimportant	64	.93	99	.99	101	1.46	108	1.08
5	Positive-Negative	47	.68	98	.98	92	1.33	77	.77
6	Wise-Foolish	48	.70	71	.71	111	1.61	130	1.30
7	Light-Heavy	-15	-.22	-43	-.43	-58	-.84	-54	-.54
8	Colorful-Colorless	43	.62	84	.84	48	.70	68	.68
9	Simple-Complex	8	.11	-51	-.51	34	.49	-69	-.69
10	Interesting-Boring	35	.51	107	1.07	70	1.01	43	.43
11	Nice-Awful	44	.64	102	1.02	93	1.35	101	1.01
12	Fair-Unfair	79	1.14	124	1.24	120	1.14	123	1.23
13	Fresh-Stale	62	.90	94	.94	62	.90	71	.71
14	Pleasing-Annoying	33	.48	81	.81	62	.90	69	.69
15	Precise-Vague	39	.56	58	.58	65	.94	90	.90
	Concept Mean	44.2	.64	73.1	.73	74.1	1.07	71.2	.71

greater than the mean scores on the concepts "What I Learned In This Science Course" (concept 1) and "How I Feel About This Science Course" (concept 2). There is, however, no test of significance available which would allow the investigator to determine whether the differences in mean scores were significant.

The Physical Science 201 students gave the concept "Science Teacher" a much higher mean score than the concept "Science Student" (difference = .43). The scales having a mean score difference greater than 0.43 for concepts 1 and 2 were the scales good-bad (difference = .68), pleasurable-painful (difference = .63), meaningful-meaningless (difference = .65), important-unimportant (difference = .52), positive-negative (difference = .65), wise-foolish (difference = .91), interesting-boring (difference = .50), nice-awful (difference = .69), and fair-unfair (difference = .60).

Physical Science students perceive their teachers as being good, pleasurable, meaningful, important, positive, wise, interesting, nice and fair more than science students.

Physical Science 301 students did not demonstrate such large differences in the mean scores for both concepts, in fact, the mean score for the concept "Science Teacher" was very close to the mean score for the concept "Science Student". The scales showing an increase in mean score in excess of 0.2 were good-bad (difference = .24) meaningful-meaningless (difference = .27), wise-foolish (difference = .59) and presice-vague (difference = .32). The scales showing a decrease in mean score in excess of 0.2 were interesting-boring (difference = .64) and fresh-stale (difference = .23).

Physical Science 301 students feel that science teachers are good, meaningful, wise and precise more than science students, however, they indicate science teachers are also more boring and stale than science students.

The scales having a mean score greater than 0.9 for the Physical Science 201 students for both concepts are good-bad, pleasurable-painful, important-unimportant, fair-unfair and fresh-stale. The concept "Science Teacher" has mean scores in excess of 0.9 not included in the concept "Science Student". These mean scores are meaningful-meaningless, positive-negative, wise-foolish, interesting-boring, nice-awful, pleasing-annoying, and precise-vague.

Physical Science 201 students feel science students and teachers are good, pleasurable, important, fair and fresh. They also feel science teachers are meaningful, positive, wise, interesting, nice, pleasing and precise.

Physical Science 301 students gave the following scales a score of 0.9 or greater for both concepts: good-bad, pleasurable-painful, important-unimportant, nice-awful, and fair-unfair. Scores in excess of 0.9 for the concept "Science Student" only are: positive-negative, interesting-boring and fresh-stale. Scores in excess of 0.9 for the concept "Science Teacher" only are: meaningful-meaningless, wise-foolish, precise-vague.

Physical Science 301 students perceive science students as good, pleasurable, important, nice, fair, positive, interesting and fresh. They perceive science teachers as good, pleasurable, important, nice, fair, meaningful, wise and precise.

Question 7

How close are each of the concepts in the semantic differential to each other in the semantic space of the 201 and 301 Physical Science students?

It is of interest to determine how the science students relate the concepts on the semantic differential. From the association it may be determined whether two concepts are significantly closer together than another two concepts in the semantic space of a student. Each concept may be correlated to another through the use of the D statistic. The smaller the value of the D statistic the closer two concepts are in the semantic space given them by students. The results of the D statistic for Physical Science 201 and 301 students are shown in tables 17 and 18.

TABLE 17

D STATISTIC FOR PHYSICAL SCIENCE 201 STUDENTS ON ALL CONCEPTS

Concept	1	2	3	4
1		.46	1.99	5.07
2	.46		1.55	6.12
3	1.99	1.55		4.44
4	5.07	6.12	4.44	

Concepts 1 and 2 are closest in the semantic space of both 201 and 301 students. The student associates what he learned in his science course most closely with how he feels about the science course he is

TABLE 18

D STATISTIC FOR PHYSICAL SCIENCE 301 STUDENTS ON ALL CONCEPTS

Concept	1	2	3	4
1		.28	3.09	1.97
2	.28		3.26	2.52
3	3.09	3.26		1.20
4	1.97	2.52	1.20	

studying. All other concepts are less closely associated with each other.

Sub-Question 7a:-Does the concept "How I Feel About This Science Course" exist more closely in the semantic space of the Physical Science 201 and 301 students to the concept "What I Learned In This Science Course" or to the concept "Science Teacher"?

If the concept "How I Feel About This Science Course" exists more closely in the semantic space to the concept "What I Learned In This Science Course" than to the concept "Science Teacher" the student considers what he learns to be more closely associated with how he feels about the science course than his attitude toward the science teacher. A test of significance can be performed between the two D statistics to determine if their positions in the semantic space of students may be considered significantly different. Osgood states that Wilcoxon test using signed ranks can be used for the analysis.

Tables 19 and 20 illustrate the results of the analysis.

TABLE 19

WILCOXON SIGNED RANKS TEST FOR PHYSICAL SCIENCE 201 STUDENTS

	number of non zero differences		Smaller sum of like-signed ranks		Probability that the sum of like-signed ranks is less than or equal to the smaller sum	
	D_{12}	D_{24}	D_{12}	D_{24}	D_{12}	D_{24}
D_{12}	0	67	0.0	259.5	1.0	0.000
D_{24}	67	0	259.5	0.0	0.000	1.0

$p<.05$

TABLE 20

WILCOXON SIGNED RANKS TEST
FOR PHYSICAL SCIENCE 301 STUDENTS

	Number of non zero differences		Smaller sum of like-signed ranks		Probability that the sum of like-signed ranks is less than or equal to the smaller sum	
	D_{12}	D_{24}	D_{12}	D_{24}	D_{12}	D_{24}
D_{12}	0	83	0.0	675.0	1.0	0.000
D_{24}	83	0	675.0	0.0	0.000	1.0

$p<.05$

Ho 3.1 There is no significant difference in the proximity of semantic space for the concepts "How I Feel About This Science Course" and "What I Learned In This Science Course" (D_{12}) and the concepts "How I Feel About This Science Course" and "Science Teacher" (D_{24}) for Physical Science 201 students as measured by Osgood's D statistic and the Wilcoxon signed pairs test of significance.

Ho 3.2 There is no significant difference in the proximity of semantic space for the concepts "How I Feel About This Science Course" and "What I Learned In This Science Course" (D_{12}) and the concepts "How I Feel About This Science Course" and "Science Teacher" (D_{24}) for Physical Science 301 students as measured by Osgood's D statistic and the Wilcoxon signed pairs test of significance.

The Wilcoxon signed pairs test for null hypotheses Ho 3.1 and Ho 3.2 resulted in both being rejected at the .05 probability level. The D statistics for concepts 1 and 2 are found to be significantly closer together in the semantic space of the student than the D statistics for concepts 2 and 4.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

SUMMARY

In this investigation 174 students enrolled in the Physical Science program which was being offered during the second semester in Manitoba were tested on achievement and attitude over a period of four months. The Physical Science program itself was also subjected to scrutiny by the investigator.

The purpose of the study was the evaluation of the Physical Science program on the basis of stated criteria. The criteria involved an assessment of the philosophy of the Physical Science program as it related to the objectives stated in the program outline; an assessment of the cognitive level of the objectives and their demands on the student in the achievement tests; an assessment of the degree of achievement in certain units and its relation to the sex and location of the students; an assessment of student and teacher attitude toward the program; and an assessment of student attitude toward science students and science teachers. As the affective domain is considered an important part of a program an extensive analysis of student and teacher attitudes was performed.

The statistical analysis was performed by computer when the analysis was complex. The programs used were the biomedical statistical packages BMDP2V and BMDP3S, both of which were available at the University of Manitoba. The analyses performed on the semantic differential were based on Osgood's suggested techniques. All null hypotheses were accepted or rejected at the .05 level of significance.

Each question will be stated in the summary; the sub-questions and hypotheses will be discussed without restatement under the major question.

Question 1

How well do the instructional objectives stated in the Physical Science program outline represent the philosophy of the 201 and 301 physical science courses?

The majority of the objectives satisfy the first two categories which deal with the understanding of basic concepts and the development of inquiry skills. It was discovered that most objectives dealing with basic concepts could easily be used in an inquiry approach by the teacher. For this reason many of the objectives were placed in category two. Category three was found to be satisfied by only 6 per cent of the objectives in the Physical Science 201 program, however, the Physical Science 301 program had from 26 to 33 per cent of the objectives satisfying category three, depending on the units a teacher elected to follow. The greater per cent satisfaction may be attributed to the optional units 2b alternatives one or two, unit 5, and unit 6. The emphasis on the social and environmental aspects of the science studied in these units accounted for the larger number of objectives being placed in category three for the Physical Science 301 program.

Generally, the majority of the objectives were placed in categories one and two. Very few instructional objectives in the Physical Science 201 program were placed in category three.

Question 2

What is the distribution of cognitive levels, as illustrated in the "Description of Instruments", for the instructional objectives stated in the Physical Science program outline?

The first cognitive level contained 58 per cent of the Physical Science 201 and 62 per cent of the Physical Science 301 objectives. The second cognitive level contained 42 per cent of the Physical Science 201 and 38 per cent of the Physical Science 301 objectives.

The two programs contained similar proportions of objectives in each cognitive level.

Question 3

To what degree are students achieving the instructional objectives stated in the Physical Science program outline?

Students in both levels of the Physical Science program displayed similar levels of achievement. Questions relating to objectives in the lower cognitive level were achieved by 56.6 per cent and 53.4 per cent of the students in the Physical Science 201 and 301 programs respectively. Questions relating to the higher cognitive level were achieved by 49.8 per cent and 44.8 per cent of the students in the Physical Science 201 and 301 programs respectively.

The smaller percentage of students correctly answering the questions relating to higher cognitive level objectives was anticipated by the investigator.

The students did not achieve at the rates described previously as desirable in the analysis of question 3.

Question 4

Does the sex of the students or their location in rural or urban schools have any effect on their achievement test scores?

The utilization of the ANOVA with repeated measures on achievement tests used in the analysis indicated the following results:

The analysis of the data did not reveal any relationship between the sex of the students and their achievement test scores for Physical Science 201 and 301 students or between the location of the student and achievement test scores for Physical Science 201 students. There was a significant difference in achievement test scores between rural and urban students for Physical Science 301 students. The urban students were achieving significantly higher scores than rural students.

Null hypotheses Ho 1.1, Ho 1.2, and Ho 1.3 were not rejected. Null hypothesis Ho 1.4 was rejected.

Question 5

What are student and teacher attitudes toward the Physical Science 201 and 301 programs?

The semantic differential was scored using +3 as high positive attitude, -3 as high negative attitude and zero as neutral attitude. The concepts "What I Learned (Taught) In This Science Course" (concept 1) and "How I Feel About This Science Course" (concept 2) were used for analysis.

Physical Science 201 and 301 students gave concepts 1 and 2 similar mean scores. No test of significance is available for one group and two concepts but a correlation technique called the D statistic can be used. The D statistic for concepts 1 and 2 is 0.46 and 0.28 (tables 17 and 18) for Physical Science 201 and 301 students respectively. The mean scores for teachers on the two concepts are similar and the D statistic is 0.74. The D statistics indicate the two concepts are close together in the students' and teachers' semantic space.

Physical Science 201 and 301 students gave the highest mean scores to the scales good-bad, important-unimportant, wise-foolish, and fair-unfair. The lowest scores were given to the scales light-heavy and simple-complex. Teachers also rated the light-heavy and simple-complex scales lowest; these two scales were the only ones receiving negative values for students and teachers. The scales other than the ones mentioned were generally rated higher by teachers than by students.

Graphs 1 and 2 indicate the mean scores for the Physical Science 201 and 301 students were almost identical. The two groups of students were considered a single sample in a test of significance for concepts 1 and 2 with teachers. A chi square median test with Yate's correction did not reveal any significant relation in the frequency of response for students and teachers on concepts 1 and 2. Null hypotheses Ho 2.1 and Ho 2.2 were not rejected.

Tables 12 and 13 indicate that Physical Science 201 males have a higher positive attitude than females toward the program but the reverse is true in the Physical Science 301 program. The increase in female positive attitude is accompanied by a decrease in enrollment which may help explain the change. It is possible the female students with a lower positive attitude toward the Physical Science program did not reregister for the course after having finished Physical Science 201. It is also possible that the Physical Science 301 program had more appeal for the female students.

A chi square test of significance failed to reveal a significant relationship between male and female students in their attitude toward the Physical Science program as indicated on concepts 1 and 2.

Null hypothesis Ho 2.3 and Ho 2.4 were not rejected.

Question 6

What are the attitudes of Physical Science 201 and 301 students toward science students and science teachers as measured by the semantic differential on the concepts "Science Student" and Science Teacher"?

Physical Science 201 and 301 students gave each concept described above a positive mean score. Physical Science 201 students did not rate the two concepts close together in semantic space (D = 4.44); whereas Physical Science 301 studnets placed the two concepts closer together in semantic space (D = 1.2).

The mean scores for Physical Science 201 and 301 students were higher for the concepts "Science Student" and"Science Teacher" than they were for the concepts "How I Feel About This Science Course" and "What I Learned In This Science Course".

Question 7

How close are each of the concepts in the semantic differential to each other in the semantic space of the 201 and 301 Physical Science students?

The results of the analysis shown in tables 17 and 18 indicate that students in both Physical Science programs associate concepts 1 and 2 most closely.

Physical Science 201 students cluster concepts 1, 2 and 3 close together. Concept 4 does not cluster with any concept in the semantic space of the Physical Science 201 students.

Physical Science 301 students cluster concepts 1, 2 and 4 and concepts 3 and 4 close together in their semantic space.

The Wilcoxon signed pairs analyses revealed that both 201 and 301 Physical Science students associate what they learn in their science course more closely than they associate science teachers with how they feel about the science course.

CONCLUSIONS

The conclusions are stated on the basis of their support for the criteria established for program success described in chapter one.

<u>Criterion 1</u> The instructional objectives stated in the Physical Science program outline fulfill the general goals and philosophy of the committee which developed the program.

The Physical Science 301 program instructional objectives fulfilled the philosophy and goals of the program. The Physical Science 201 progarm instructional objectives did not fulfill the philosophy and goals of the program. The third category, containing objectives relating to the interrelationship of science and other disciplines did not contain an adequate number of objectives. The other two categories representing program philosophy were adequately fulfilled.

Criterion 2 A stated percentage of students are able to successfully complete the instructional objectives stated in the Physical Science program outline.

An adequate number of instructional objectives were found in each cognitive level analyzed for both the Physical Science 201 and 301 programs. The four unit tests used in the analysis of student achievement of instructional objectives revealed that the Physical Science 201 and 301 students did not attain the arbitrarily chosen achievement level for both cognitive levels.

Criterion 3 The attitude of the students toward the program of study is favorable.

Both the Physical Science 201 and 301 students indicated a positive attitude toward the program as shown in the positive mean score for all scales in the concepts "What I Learned In This Science Course" and and "How I Feel About This Science Course". The attitude profile shown in graphs 1 and 2 are similar as both grades indicate in a like manner that the program is favorable.

The favorable attitude as shown in the concept "How I Feel About This Science Course" is associated significantly more closely to what the students perceived they learned in their science course than to how they perceived their science teachers. No relationship could be determined between male and female students in their attitudes toward the Physical Science 201 and 301 programs as shown on the concept "How I Feel About This Science Course". Null Hypotheses Ho 2.3 and Ho 2.4 could not be rejected indicating that enough evidence to state a relationship existed could not be found.

Student attitude toward the program of studies is not as favorable as their attitude toward science students and science teachers as indicated by the mean scores on all four concepts.

Criterion 4 The attitude of the teachers toward the program of studies is favorable.

The results of the survey indicate that teachers have a positive attitude toward the Physical Science program as shown by their positive mean score on the concepts "What I Learned In This Science Course" and "How I Feel About This Science Course". No relationship between Physical Science students and teachers could be determined on either of the concepts described above. Null hypothesis Ho 2.1 and Ho 2.2 could not be rejected as enough evidence to state a relationship existed could not be found.

It is important to note, however, that both students and teachers felt the program was heavy and complex as indicated on the scales light-heavy and simple-complex for the two concepts used to measure attitude toward the Physical Science program.

Criterion 5 Student achievement of the instructional objectives has no relation to the sex of the student and to his location in either a rural or urban school.

No evidence could be found through analysis of variance that the variables sex of the student and location of the student in rural or urban schools had any effect on the achievement test scores of Physical Science 201 students, nor that the variable sex of the student had any effect on the achievement test scores of the Physical Science 301 students. The analysis of variance revealed, however, that urban Physical Science

301 students were receiving significantly higher scores on achievement tests than rural Physical Science 301 students. Consequently, the results of the analysis for Physical Science 201 students give no evidence to refute criterion 5. The results of the analysis for Physical Science 301 students refutes criterion 5. Limitations on the study in the form of small sample size and semesterized programs may have affected the results of the analysis.

Generally, it may be concluded on the basis of this evidence that the Physical Science program is not entirely successful. The Physical Science 201 program does not satisfy criteria one and two; the Physical Science 301 program does not satisfy criteria two and five. There is no evidence that the sex of the student affects achievement test results in both grades, nor that the location of the student affects achievement test results for Physical Science 201 students. However, it cannot be concluded that no relationship exists, but rather that in this study utilizing the instruments described, no evidence of a relationship between the stated variables could be found.

IMPLICATIONS

Implications For The Physical Science Program

1. There should be an attempt to develop the instructional objectives of the Physical Science 201 program to include that portion of the program philosophy which states there should be an opportunity for students "to examine the interaction of science and society within the context of a number of disciplines."

2. The requirements for criterion two, as stated below, may have been unrealistic.

   > A stated percentage of students are able to successfully complete the instructional objectives stated in the course outline for each unit.

   The achievement test scores of the students on both cognitive levels identified suggests that many students in both programs are not successfully completing the instructional objectives. There should be an attempt to provide alternative instructional objectives that could be used with classes or groups of students who do not require a concentration on a mathematical approach to understanding concepts.

Implications For Further Research

The results of this study indicate a number of areas which may be further investigated.

1. The discrepancy in the results of the analysis determining the relationship between location of the student and achievement test scores for Physical Science 201 and 301 students suggests further study.

2. The mean scores for the concepts and scales on the semantic differential provide a base for comparative research in other science programs using the sementic differential.

3. The difference in semantic space that students delegate to the concepts "How I Feel About This Science Course" and "What I Learned In This Science Course" and to the concepts "How I Feel About This Science Course" and "Science Teacher" could be further investigated in other programs. It could be determined if the significantly greater perceived association between the first two concepts described exists in other science programs.

4.

4. Teacher attitudes as measured on the concepts "Science Student" and "Science Teacher" could be investigated in relation to their attitudes toward a science program and in relation to student attitudes as measured by the semantic differential.

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APPENDIX A

TABLE 21

CELL NUMBERS, MEANS, AND STANDARD DEVIATIONS ON THE DEPENDENT VARIABLE (ACHIEVEMENT TEST SCORES)

Sex	Male	Female	Male	Female	Mean
Location	Rural	Rural	Urban	Urban	
Test 1	37.84000	35.85713	49.68626	53.25000	46.00000
Test 2	43.67999	47.42856	50.17647	48.58333	48.06316
Test 3	49.51999	48.28571	57.39215	50.16666	53.73683
Mean	43.67999	43.85713	52.41829	50.66666	49.26666
Number of students	25	7	51	12	95

STANDARD DEVIATIONS FOR THE DEPENDENT VARIABLE

Sex	Male	Female	Male	Female
Location	Rural	Rural	Urban	Urban
Test 1	11.55667	12.29401	14.56220	12.39593
Test 2	16.07201	11.55937	15.25604	16.11581
Test 3	14.51756	21.47644	19.26659	16.44734

TABLE 22

CELL NUMBERS, MEANS, AND STANDARD DEVIATIONS ON THE DEPENDENT VARIABLE (ACHIEVEMENT TEST SCORES)

Sex Location	Female Rural	Male Rural	Female Urban	Male Urban	Mean
Test 1	49.85713	57.77777	35.20000	43.81818	48.77965
Test 2	48.85713	52.72221	57.79999	47.77272	50.38982
Test 3	62.57143	60.77777	63.20000	60.90909	61.45763
Mean	53.76190	57.09259	52.06667	50.83333	53.54236
Number of students	14	18	5	22	59

STANDARD DEVIATIONS FOR THE DEPENDENT VARIABLE

Sex Location	Female Rural	Male Rural	Female Urban	Male Urban
Test 1	11.96056	12.21164	16.82854	16.97232
Test 2	11.67414	10.87796	18.01942	17.78688
Test 3	11.90807	12.67028	19.05780	16.83223

APPENDIX B

UM

The University of Manitoba
Faculty of Education

Department of Curriculum
Mathematics and Natural Sciences

Winnipeg, Manitoba, Canada R3T 2N2

November 29, 1974

To the Superintendent of Schools:

Mr. Garth Martin is a Graduate Student in the Department of Curriculum Mathematics and Natural Sciences at Faculty of Education.

His research for his thesis necessitates some data collection in the schools. His requisition for permission to collect data will explain the details.

Thank you for your cooperation.

Yours sincerely

Dr. K. Slentz

KS/djp

UM

The University of Manitoba
Faculty of Education

Department of Curriculum
Mathematics and Natural Sciences

Winnipeg, Manitoba, Canada R3T 2N2

December 2, 1974

To the Superintendent of Schools:

This is a request for permission to contact the secondary school principals involved in the new 201 and 301 Physical Science Program in your division.

Please find enclosed a copy of the letter that would be sent to the principals and science teachers upon your approval of this request.

Would you kindly complete the form below and return at your earliest convenience.

Yours sincerely,

Garth Martin

GM/djp

Wpg., Man.
R

Permission granted ▭ Permission not granted ▭

School(s) Principal(s) Address(es)

Superintendent: ______________________

APPENDIX C

UM

The University of Manitoba
Faculty of Education

Department of Curriculum
Mathematics and Natural Sciences

Winnipeg, Manitoba, Canada R3T 2N2

December 2, 1974

To the Principal and Physical Science Teachers:

A new science program has been developed by M. Spector and his committee for 201 and 301 students in Manitoba. As part of my Master's Program in Education at the University of Manitoba, I am attempting to evaluate the new Physical Science 201 and 301 Program.

In order to complete the evaluation a survey of both rural and urban students is required. This is a request for your school to allow the students enrolled in the 201 and 301 science program to be part of the evaluation sample.

The schools needed for this survey must have two characteristics:

1) they are semesterized
2) they are using the new 201 and/or 301 Physical Science Program in the second semester.

According to my information your school satisfied these requirements. If this is not the case their please indicate on the request form at the end of this letter. Your assistance in this evaluation would be greatly appreciated.

The following points indicate the procedure for this survey.

1) Multiple choice tests have been constructed for the 201 and 301 physical science units. These tests will be sent to participating schools.
2) A template will be supplied with the answer sheets . This will allow the teacher to correct the tests easily if he wants to use them for student assessment. The answer sheets should then be mailed to me for analysis.
3) A short (4 question) questionnaire will be sent for the teacher to complete after finishing the two optional units which do not have multiple choice tests.

4) A short (15 minute) attitude survey will be sent to the schools at the end of May. The attitude test should be completed by both students and teachers.

I have attempted keeping the teacher workload and classroom interference to a minumum. The survey is an attempt to evaluate the physical science program, not schools or teachers. The results of the evaluation will be sent to all participating schools.

Would you complete the permission slip included on the following page?

Thank-you for your cooperation.

Yours sincerely,

Garth Martin

GM/djp

REQUEST FORM

This school (does ______) (does not _____) offer the new Physical Science Program in the second semester.

This school (does ______) (does not _____) agree to assist in the evaluation of the 201 and 301 Physical Science Program.

If your school does agree to assist in the evaluation will you answer the following questions?

1. When does the second semester begin?

   ____

2. What is the anticipated number of students enrolled in the second semester?

   Physical Science 201 ________________________

   Physical Science 301 ________________________

3. Who are the teachers involved in instructing the two programs?

   ____

   ____

   ____

4. Signature of the principal

   ____

Would you return this information as soon as possible to:

Mr. Garth Martin

Winnipeg, Manitoba R

APPENDIX D

TO THE INSTRUCTOR

I would like to thank you for taking the time and making the effort to help with this program evaluation. I hope the results of the investigation that will be sent to your school will make the effort worthwhile. A few comments are included in order to clarify any questions that you may have. Please retain this letter for future reference.

1) In order to reduce the cost and time involved with mailing, all the tests for one student can be answered on a single IBM answer sheet. This means a class of 20 students would require 20 answer sheets for the whole testing program.

   The numbers beside the test questions correspond to the numbers on the answer sheet. This should reduce the possibility of a student filling in the wrong space.

   If you are not following the chapter sequence in the outline there should be no problem since the test questions have been assigned to particular spaces on the answer sheet. <u>The students should be cautioned, however, before the test begins to make sure they are</u>

answering the questions in the correct spaces.

The spaces on the IBM answer sheets need to be filled in with a pencil rather than a pen. I noticed also the lines are horizontal on the answer sheet instead of vertical as suggested on the test.

2) Answer templates are supplied and indicate what seem to me to be the correct answer. If you are using the tests for your own student assessment I would ask you not to mark the answer sheets.

3) If you feel a question on a test is not relevent to what you have taught then leave it out. However, if you could keep these to a minimum it would help validate the investigation results.

4) Would you ask the students to fill in the following spaces:

295	(A)	female	(B)	male	
296	(A)	rural	(B)	urban	rural = any school outside Winnipeg
297	(A)	201	(B)	301	

5) Administer the attitude test in the first week of May.

6) The teacher questionnaire is for 301 science only and refers to units 3 and 6.

7) Time chart.

RETURN AT THE END OF MAY	a) unit tests	- administer at the end of each unit and return the IBM sheets when the units are finished or the end of May, whichever comes first.
	b) teacher questionnaire	- fill in when units 3 and 6 are covered and return with IBM answer sheets.
RETURN AT THE BEGINNING OF MAY →	c) attitude survey	- administer and return in the beginning of May.

8) Would you return the material to

Garth Martin

Winnipeg, Manitoba
R

If I have not explained something clearly or if there are any problems please contact me at the above address.

To The Instructor

1. Read through the instructions and do the test before the students do theirs. Hand in your responses along with the students.

2. Read through the instructions with the students. If there are any questions answer them before continuing.

3. Place no time limit on the students. Allow them to finish in whatever time it takes.

4. For the first concept the instructor showed use the statement "What I taught in science."

5. Note that scales numbered (3), (5), (7), (9), (11) and (14) are considered reversed.

Attitudes Toward A Science Program

The purpose of this study is to measure your attitude toward the Science program you are now taking by having you judge certain ideas against a series of descriptive scales. In taking this test, please make your judgements on the basis of what these ideas mean to you. On each page of this booklet you will find a different idea to be judged and beneath it a set of scales. You are to rate the idea on each of these scales in order.

Here is how to use these scales:

If you feel the concept at the top of the page is very closely related to one end of the scale you should place your check mark as follows:

Fair X : _ : _ : _ : _ : _ : _ Unfair

or

Fair _ : _ : _ : _ : _ : _ : X Unfair

If you feel that the concept is quite closely related to one or the other end of the scale (but not extremely), you should place your check-mark as follows:

Good _ : X : _ : _ : _ : _ : _ Bad

or

Good _ : _ : _ : _ : _ : X : _ Bad

If the concept seems only slightly related to one side as opposed to the other side (but is not really neutral), then you should check as follows:

Important _ : _ : X : _ : _ : _ : _ : Unimportant

or

Important _ : _ : _ : _ : X : _ : _ : Unimportant

The direction toward which you check, of course, depends upon which of the two ends of the scale seem most characteristic of the concept you are judging.

If you consider the concept to be neutral on the scale, both sides of the scale equally related to the concept, or if the scale is not in any way related to the concept, then you should place your check mark in the middle space:

Pleasant _ : _ : _ : X : _ : _ : _ Unpleasant

IMPORTANT: 1) Place your check marks in the middle of spaces, not on the boundaries

This X Not This

: X : _ : _ : _ : _ : _ : _

2) Be sure to check every scale for every concept - do not omit any

3) Never put more than one check mark for each scale.

4) Some of the scales are reversed

Sometimes you may feel as though you have had the same item before on the test. This will not be the case, so do not look back and forth through the items. Do not try to remember how you checked similar items earlier in the test. Make each item a separate and independent judgement. Work at a fairly high speed through this test. Do not worry or puzzle over individual items. It is your first impressions, the immediate "feelings" about the items, that we want. On the other hand, please do not be careless, because we want your true impression.

What I Learned in This Science Course

1) Good _ : _ : _ : _ : _ : _ : _ Bad

2) Pleasurable _ : _ : _ : _ : _ : _ : _ Painful

3) Meaningless _ : _ : _ : _ : _ : _ : _ Meaningful

4) Important _ : _ : _ : _ : _ : _ : _ Unimportant

5) Negative _ : _ : _ : _ : _ : _ : _ Positive

6) Wise _ : _ : _ : _ : _ : _ : _ Foolish

7) Heavy _ : _ : _ : _ : _ : _ : _ Light

8) Colorful _ : _ : _ : _ : _ : _ : _ Colorless

9) Complex _ : _ : _ : _ : _ : _ : _ Simple

10) Interesting _ : _ : _ : _ : _ : _ : _ Boring

11) Awful _ : _ : _ : _ : _ : _ : _ Nice

12) Fair _ : _ : _ : _ : _ : _ : _ Unfair

13) Fresh _ : _ : _ : _ : _ : _ : _ Stale

14) Annoying _ : _ : _ : _ : _ : _ : _ Pleasing

15) Precise _ : _ : _ : _ : _ : _ : _ Vague

How I Feel About This Science Course

1)	Good	_ : _ : _ : _ : _ : _ : _	Bad
2)	Pleasurable	_ : _ : _ : _ : _ : _ : _	Painful
3)	Meaningless	_ : _ : _ : _ : _ : _ : _	Meaningful
4)	Important	_ : _ : _ : _ : _ : _ : _	Unimportant
5)	Negative	_ : _ : _ : _ : _ : _ : _	Positive
6)	Wise	_ : _ : _ : _ : _ : _ : _	Foolish
7)	Heavy	_ : _ : _ : _ : _ : _ : _	Light
8)	Colorful	_ : _ : _ : _ : _ : _ : _	Colorless
9)	Complex	_ : _ : _ : _ : _ : _ : _	Simple
10)	Interesting	_ : _ : _ : _ : _ : _ : _	Boring
11)	Awful	_ : _ : _ : _ : _ : _ : _	Nice
12)	Fair	_ : _ : _ : _ : _ : _ : _	Unfair
13)	Fresh	_ : _ : _ : _ : _ : _ : _	Stale
14)	Annoying	_ : _ : _ : _ : _ : _ : _	Pleasing
15)	Precise	_ : _ : _ : _ : _ : _ : _	Vague

Science Student

1)	Good	_ : _ : _ : _ : _ : _ : _	Bad
2)	Pleasurable	_ : _ : _ : _ : _ : _ : _	Painful
3)	Meaningless	_ : _ : _ : _ : _ : _ : _	Meaningful
4)	Important	_ : _ : _ : _ : _ : _ : _	Unimportant
5)	Negative	_ : _ : _ : _ : _ : _ : _	Positive
6)	Wise	_ : _ : _ : _ : _ : _ : _	Foolish
7)	Heavy	_ : _ : _ : _ : _ : _ : _	Light
8)	Colorful	_ : _ : _ : _ : _ : _ : _	Colorless
9)	Complex	_ : _ : _ : _ : _ : _ : _	Simple
10)	Interesting	_ : _ : _ : _ : _ : _ : _	Boring
11)	Awful	_ : _ : _ : _ : _ : _ : _	Nice
12)	Fair	_ : _ : _ : _ : _ : _ : _	Unfair
13)	Fresh	_ : _ : _ : _ : _ : _ : _	Stale
14)	Annoying	_ : _ : _ : _ : _ : _ : _	Pleasing
15)	Precise	_ : _ : _ : _ : _ : _ : _	Vague

Science Teacher

1)	Good	_ : _ : _ : _ : _ : _ : _	Bad
2)	Pleasurable	_ : _ : _ : _ : _ : _ : _	Painful
3)	Meaningless	_ : _ : _ : _ : _ : _ : _	Meaningful
4)	Important	_ : _ : _ : _ : _ : _ : _	Unimportant
5)	Negative	_ : _ : _ : _ : _ : _ : _	Positive
6)	Wise	_ : _ : _ : _ : _ : _ : _	Foolish
7)	Heavy	_ : _ : _ : _ : _ : _ : _	Light
8)	Colorful	_ : _ : _ : _ : _ : _ : _	Colorless
9)	Complex	_ : _ : _ : _ : _ : _ : _	Simple
10)	Interesting	_ : _ : _ : _ : _ : _ : _	Boring
11)	Awful	_ : _ : _ : _ : _ : _ : _	Nice
12)	Fair	_ : _ : _ : _ : _ : _ : _	Unfair
13)	Fresh	_ : _ : _ : _ : _ : _ : _	Stale
14)	Annoying	_ : _ : _ : _ : _ : _ : _	Pleasing
15)	Precise	_ : _ : _ : _ : _ : _ : _	Vague

Please check the appropriate squares.

Male	Female
☐	☐
Urban	Rural
☐	☐
201	301
☐	☐

PHYSICAL SCIENCE 201 - OBJECTIVE TEST

UNIT I and II

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

1. Which of the following is an example of disorder in nature:

   (a) seasons of the year (b) ocean tides (c) phases of the moon
   (d) flat water surfaces (e) none of these choices

2. Weather forecasting is not totally successful because:

   (a) there are too many factors to consider (b) not enough is known about the weather (c) not all information is available (d) two of the above choices are correct (e) choices (a), (b), and (c) are correct.

3. A visitor from a strange planet wishes to classify earth people according to major differences. Which of the following would be the BEST basis for classification?

   (a) religion (b) sex (c) nationality (d) occupation (e) education

The following choices are for questions 4 to 8:
(a) Humanities and science
(b) Humanities and fine arts
(c) Science and fine arts
(d) Humanities, science, and fine arts
(e) None of these

Which of the above choices BEST relates to each of the following activities?

4. Writing a novel about interplanetary travel.

5. Designing and planning a hydro-electric project.

6. Designing and planning a world's fair.

7. Fitting the pieces of a jigsaw puzzle.

8. Writing a novel about the Riel Rebellion.

The following choices are for questions 9 to 13:
(a) Chemistry (b) Physics (c) Astronomy (d) Biology (e) Geology

9. The motion of a baseball.

10. The study of rocks.

11. Describing how a photographic film is developed.

12. Developing a variety of new wheat.

13. Discovery of a new planet.

14. Early Egyptians had difficulty in describing the motions of heavenly bodies because:

    (a) They were superstitious.
    (b) Their religion interfered.
    (c) They thought the earth was stationary in space.
    (d) Their instruments were primitive.
    (e) They thought the earth was moving in space.

15. The term "Geocentric Universe" means that the stationary center of the universe is the:

    (a) Sun (b) Moon (c) Stars (d) Earth (e) Planets

16. Which of the choices of question #15 would describe a "Heliocentric Universe".

17. The first person to describe the solar system as being heliocentric was:

    (a) Aristotle (b) Copernicus (c) Eudoxus (d) Einstein
    (e) Ptolemy

The following choices are for questions 18 to 21.

(a) Rotation of earth on its axis using the sun as a reference point.
(b) Rotation of earth on its axis using the moon as a reference point.
(c) Rotation of earth on its axis using the stars as reference objects.
(d) Revolution of earth around sun.
(e) Revolution of moon around earth.

Which of the above choices define each of the following?

18. Siderial day.
19. Month.
20. Solar day.
21. Year.

22. The Julian calendar replaced the early Roman calendar because:

    (a) A year does not have a whole number of months.
    (b) A year does not have a whole number of days.
    (c) A month does not have a whole number of days.
    (d) The year was too long.
    (e) A religious agreement could be settled.

23. Which choice of question #22 explains why the Gregorean calendar replaced the Julian calendar?

24. The calendar we use is called:

    (a) Solar (b) Lunar (c) Lunisolar (d) Solilunar (e) Geolunar

25. Which of the following were leap years according to BOTH the Julian and Gregorean calendars?

    (a) 1600 (b) 1700 (c) 1800 (d) 1900 (e) 1902

PHYSICAL SCIENCE 201 - OBJECTIVE TEST

UNIT III

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

41. The number one million when expressed as 1×10^{6} is referred to as:

    (a) power of ten notation
    (b) exponential notation
    (c) scientific notation
    (d) arithmetic notation
    (e) more than one of the above

42. The number 10,000,000,000 expressed in scientific notation is best described as:

    (a) 10×10^{9} (b) 10×10^{-9} (c) 10^{10} (d) 1×10^{10}
    (e) 1×10^{-10}

43. The population of Canada in a particular year was approximately twenty-two million. Which of the following best expresses this quantity as a power of ten:

    (a) 2.2×10^{5} (b) 22×10^{5} (c) 2.2×10^{6} (d) 2.2×10^{7}
    (e) 22×10^{6}

44. The number .000005 can best be written in scientific notation as:

    (a) 5.0×10^{-6} (b) 5.0×10^{-5} (c) 5.0×10^{6} (d) $\frac{5}{1,000,000}$
    (e) 50×10^{5}

45. The number 5.23×10^{8} when changed to an exponent of 10^{3} is written as:

    (a) $.0000523 \times 10^{3}$ (b) 523000×10^{3} (c) $.00000523 \times 10^{3}$
    (d) 5.23×10^{3} (e) 5230000×10^{3}

46. A day is defined as 81,400 seconds. Which of the following represents 100 days:

    (a) 8.14×10^{2} sec. (b) 8.14×10^{-2} sec. (c) 8.14×10^{6} sec.
    (d) 8.14×10^{-6} (e) None of the above.

47. Which of the choices in question #6 represents a hundredth of a day?

48. The value of all goods and services produced in Canada is called the Gross National Product. The Gross National Product of Canada in one particular year was 100 billion dollars. The population at that time was 20 million people. The Gross National Product per person that year was:

    (a) 2×10^{18} dollars/person (b) 5×10^{4} dollars/person
    (c) 5×10^{2} dollars/person (d) 5×10^{3} dollars/person
    (e) 5×10^{4} dollars/person

49. 5.80×10^{-3} was multiplied by 6.00×10^{8} is best described as:

(a) 3.48×10^{5} (b) 3.48×10^{6} (c) 34.8×10^{5} (d) 34.8×10^{-5}
(e) 3.48×10^{11}

50. To the nearest order of magnitude how many railroad ties are there between Winnipeg and Toronto (1500 miles). Railroad ties are approximately 1 foot apart.

(a) 10^{5} (b) 10^{7} (c) 10^{8} (d) 10^{4} (e) 10^{6}

51. A hockey rink ice surface is about 100 feet by 200 feet. Estimate to the nearest order of magnitude the number of 25 cent pieces which would be required to cover the ice surface of Maple Leaf Gardens at Toronto.

(a) 10^{4} (b) 10^{5} (c) 10^{6} (d) 10^{7} (e) 10^{8}

52. Which of the following is of the order of magnitude of 10^{8}?

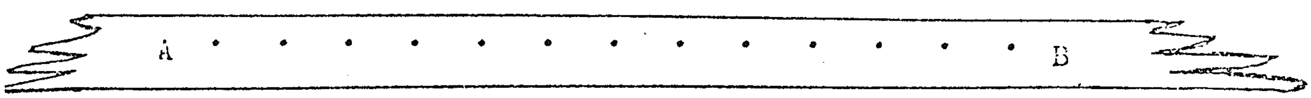
(a) 8,000 (b) 0.00000008 (c) 8,000,000 (d) 800,000,000
(e) None of the above.

53. Which of the choices in question #12 is of the order of magnitude 10^{-8}?

54. Which of the choices in question #2 is expressed as an order of magnitude?

(a) (b) (c) (d) (e)

55. Household current occurs in pulses of 60 cycles per second. Recording timers can be made to run in accordance with the cycles (one tick each cycle). The time it takes to pull the following tape from A to B would be nearest to:



(a) .1 seconds (b) .2 seconds (c) .3 seconds (d) .4 seconds
(e) .5 seconds

56. A pendulum completes 15 swings in 7.5 seconds. It is observed that a boy walks around the room in 300 swings of the pendulum. The length of time it takes the boy to walk around the room is:

(a) 1.5 seconds (b) 150 seconds (c) 75 seconds (d) 7.5 seconds
(e) 37.5 seconds

57. A twelve slit stroboscope rotates ten times in five seconds while a single bladed fan appears to stand still.
The frequency of the fan blade is best described as:

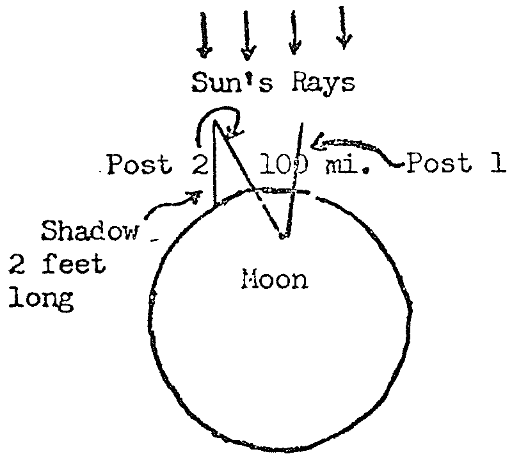
(a) 1/24 second (b) 24 cycles per second (c) 24 seconds
(d) 1/12 second (e) 12 per second

58. Which of the above choices best describes the period of the rotating fan blade?

59. Which of the following could the stroboscope best be used to measure?

(a) The rate of rotation of an automobile wheel.
(b) The period of a pendulum.
(c) The speed of a moving car.
(d) The diameter of an automobile wheel.
(e) The speed of sound.

60.



An astronaut orbiting the moon sees two posts on the moon 100 miles apart. The poles are known to be 20 feet high. Post #1 casts no shadow, post #2 has a shadow two feet long. The radius of the moon is nearest to:

(a) 100 miles (b) 500 miles (c) 1000 miles (d) 1500 miles
(e) 2000 miles

61. Which of the following amounts of money has the greatest value?

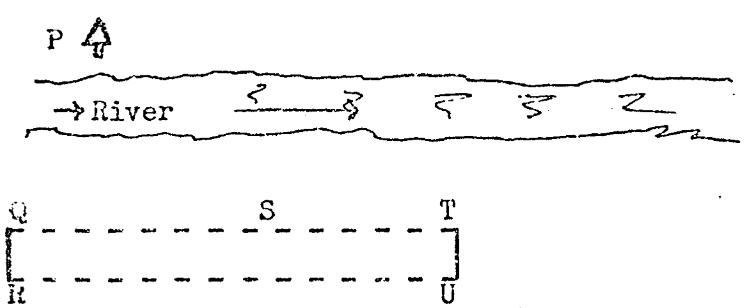
(a) microcent (b) megacent (c) kilobuck (d) millicent (e) microbuck

62. Which of the above choices has the least value:

(a) (b) (c) (d) (e)

63. The original meter was defined as:

(a) 39.4 inches
(b) 10^{-7} of the distance from the equator to the North Pole.
(c) 10^{7} of the distance from the equator to the North Pole.
(d) 10^{-7} of the circumference of the earth.
(e) 10^{7} of the radius of the earth.



64. A student uses triangulation to measure the distance P Q across a river.

Stakes are placed at Q S T U and R on his side of the river. Which of the following distances must he know to determine P Q?

(a) Q S only.
(b) P S and S T only.
(c) Q S, Q R, and R S only.
(d) R U, Q S, and S T only.
(e) Q S, S T, and T U only.

65. The student of the above question made the following measurements:

QR = 12.3 m, QS = 6.73 m, RS = 13.4 m, ST = 3.46 m,
TU = 12.3 m, RU = 10.2 m

He then calculated the distance PQ to be nearest to:
(a) 21.0 m (b) 1.89 m (c) 210 m (d) 189 m (e) 2.10 m

66. A pile of exactly 1000 sheets of paper is found to be 54 millimeters thick. The thickness of each sheet is:

(a) 5.4 cm (b) 5.4×10^{-2} cm (c) 5.4×10^{-3} cm (d) 5.4×10^{-4} cm
(e) 5.4×10^{-5} cm

67. A kilogram of mass was originally defined as:

(a) the mass of 1 cc of water.
(b) the mass of 1 ml of water.
(c) the mass of 1 m^3 of water.
(d) the mass of 1 L of water.
(e) the mass of 100 cc of water.

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

81. A worker is paid $6.00 for two hours work and $12.00 for four hours work. His pay for three hours work could be determined by a process called:

(a) Inhilation (b) Polation (c) Interpolation (d) Extrapolation
(e) Dilation

82. Which of the choices of question #1 would enable the determination of his pay for six hours work?

83. The information below is for questions 3 to 8.

Weights of gold (G) and aluminium (A) are each suspended from a hanging spring and cause amounts of stretch (S) which are recorded on the following table:

Gram Gold (G)	Corresponding Stretch (S)	Gram Aluminium (A)	Corresponding Stretch (S)
0	0	0	0
10	5	10	5
20	10	20	10
30	15	30	15
40	20	40	20

(You may find it helpful to sketch a graph.)

Consider the following statements bearing in mind the manner in which the data were taken:

I Stretch is a function of the suspended weight of gold.
II Stretch is a function of the suspended weight of aluminium.
III Stretch is a function of the kind of substance suspended.

84. With respect to the above statements:

(a) only I is correct
(b) only II is correct
(c) only III is correct
(d) I and II are both correct
(e) I, II, and III are correct.

Consider the following statements bearing in mind the manner in which the data were taken:

I Weight suspended is an INDEPENDENT VARIABLE.
II The kind of substance suspended is a DEPENDENT VARIABLE.
III The amount of stretch is an INDEPENDENT VARIABLE.

With respect to the above statements choose your answer from choices (a) to (e) of question #3.

85. A graph of S vs. G would be a straight line passing through the origin. This kind of graph is best described as:

(a) a LINEAR relation.
(b) a NON-LINEAR relation.
(c) a DIRECT proportion,
(d) an INDIRECT proportion
(e) an INDIRECT relation.

86. The slope of the graph of question #5 is:

(a) 0.5 $\frac{\text{centmeters}}{\text{gram}}$ (b) 0.5 $\frac{\text{gm.}}{\text{cm.}}$ (c) 2 $\frac{\text{gm.}}{\text{cm.}}$ (d) 2 $\frac{\text{cm.}}{\text{gm.}}$

(e) 2 $\frac{\text{gm.}}{\text{gold}}$

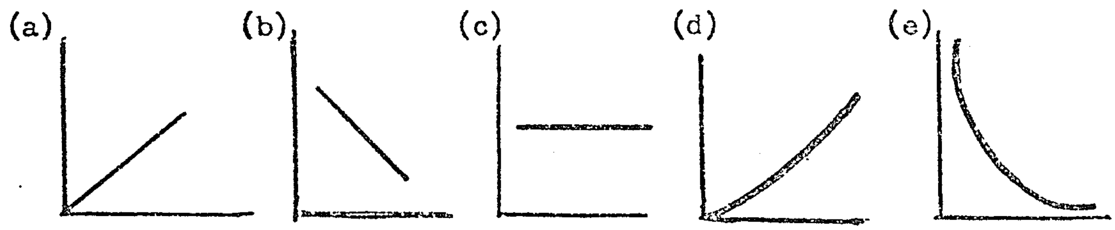
87. The SLOPE of the graph is the same as:

(a) the equation (b) the intercept (c) the proportionality constant
(d) the axes (e) the origin

88. The equation which describes this situation is:

(a) $5S = 10G$ (b) $2S = 5G$ (c) $\frac{S}{G} = 2$ (d) $S = 2G$ (e) $S = 0.5G$

Below are graph shapes for questions 9 to 22.



Select the graph shape which best describes each of the following situations.

89. Five dollars is hidden in a mattress (wealth vs. time).

90. A dime is added to a jar every day (wealth vs. time).

91. When gas pressure is doubled, the volume is halved (volume vs. pressure).

92. When the sides of a square are doubled in length, the area is four times as great (area vs. length).

93. The speed of a falling ball doubles when the time of fall doubles (speed vs. time).

Which graph shape best relates to each of the following equations:

94. $y = \frac{K}{X}$ 95. $y = Kx$ 96. $y \cong Kx^2$ 97. $y = K$ 98. $y = (-K)x$.

99. Which graph best describes each of the following sets of data:

x	0	5	10	15	20
y	5	5	5	5	5

100.

x	0	2	4	6
y	0	6	12	18

101.

x	2	4	8	10
y	100	50	25	20

102.

x	0	1	2	3	4
y	0	1	4	9	16

103. To produce a straight line graph from the data of question #20, plot:

(a) y vs. x (b) y vs. $\frac{1}{x}$ (c) y vs. x^2 (d) y^2 vs. x

(e) It can not be done.

104. Which of the choices in question #23 would produce a straight line graph from the data of question #21?

105. Which of the choices in question #23 would produce a straight line graph from the data of question #22?

PHYSICAL SCIENCE 201 - OBJECTIVE TEST

UNIT V

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

The following information applies to questions 1-3.
A number of students drew up a list of substances commonly found in the laboratory and at home.

(a) tap water
(b) alcohol (C_2H_5OH)
(c) sugar ($C_6H_{12}O_6$)
(d) aluminum (Al)
(e) table salt (NaCl)
(f) air
(g) ice
(h) gold (Au)
(i) milk
(j) CO_2
(k) oxygen (O_2)
(l) limestone ($CaCO_3$)

21. Substances (a), (f), (g), and (i) would be best classified as:
(a) solids (b) gases (c) liquids (d) mixture (e) compound

22. Substances (d), (e), (h), and (l) can be best classified as:
(a) element (b) solids (c) compounds (d) nonmetals (e) metals

23. Elements and compounds would best be exemplified by:
(a) CO_2 and $CaCO_3$ (b) H_2O and ice (c) Al and C_2H_5OH (d) Al and Au
(e) none of these apply

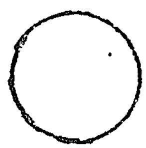
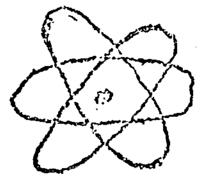
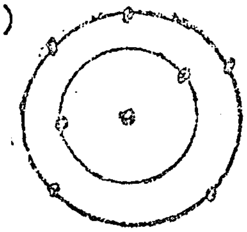
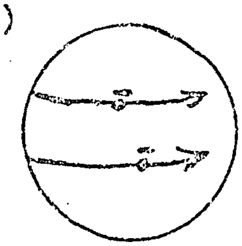
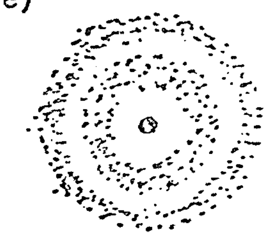
24. Matter such as gold, aluminum, oxygen, water and sugar consist of very minute and indivisible particles called:
(a) atoms (b) molecules (c) ions (d) compounds (e) two of the above are equally correct.

5. The nucleus of an atom of gold consist of:
(a) positive and negative particles.
(b) neutral particles only.
(c) negative and neutral particles.
(d) negative particles.
(e) none of the above apply.

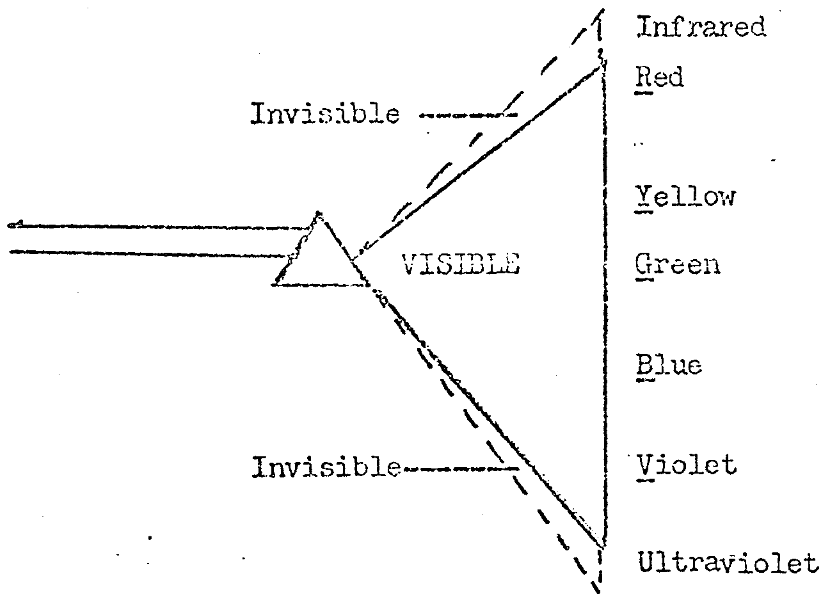
6. Rutherford in his study of the structure of an atom observed that a majority of alpha particles passed through a gold foil but a few alpha particles were scattered at various angles. On the basis of this observation, Rutherford concluded that:
(a) Matter is made up of atoms which have a dense nucleus and a large space occupied by electrons.
(b) Matter is made up of atoms which are solid but have spaces to some degree, therefore allowing the passage of alpha particles.
(c) Matter consists of atoms with a positive nucleus with electrons embedded

in the nucleus like thumbtacks on a styrofoam ball.
(d) Answer (a), (b), and (c) are equally correct.
(e) Two answers are equally correct.

127. The Bohr concept of the atom is best illustrated by:

(a) 
(b) 
(c) 
(d) 
(e) 

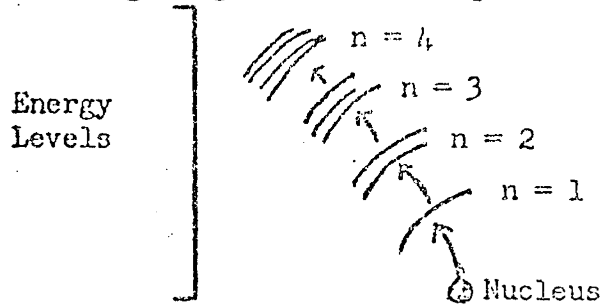
The following information refers to questions 8-9.
White light, if passed through a prism, is separated into various colors of the rainbow.



8. With reference to the spectrum infrared to ultraviolet:
(a) wavelength is decreasing and energy is increasing.
(b) wavelength is decreasing and energy is decreasing.
(c) wavelength is increasing and energy is decreasing.
(d) wavelength is increasing and energy is increasing.

9. Electromagnetic waves that make up white light are caused by:
(a) light emission from the sun.
(b) the very hot interior of the sun.
(c) electrons going into higher energy levels and returning to their stable level.
(d) radioactive sources within the sun.
(e) sources unknown.

The following diagram refers to questions #10 - 13 inclusive.



130. Emission of electromagnetic waves equivalent to high energy ultraviolet light can be explained by:
(a) fall of electron from n = 4 to n = 3.
(b) fall of electron from n = 4 to n = 1.
(c) fall of electron from n = 2 to n = 1.
(d) fall of electron n = 4 into the positive nucleus.
(e) none of these answers apply.

131. Distance between n = 1 and n = 2 is greater than distance between n = 3 and n = 4. This observation can be best explained by:
(a) the amount of energy absorbed by an electron as it moves from n = 1 to n = 2 to n = 3 to n = 4 decreases, thus the distance decreases.
(b) nuclear attraction increases with increased number of electrons and energy levels.
(c) nuclear attraction decreases as the number of electrons and energy levels increase.
(d) two of the above are equally correct.
(e) three of (a), (b), and (c) are equally correct.

32. Using the formula $2n^2$, calculate the number of electrons in level n = 4:
(a) 32 (b) 18 (c) 8 (d) 2 (e) 64

33. Level n = 3 has orbitals that are identified as:
(a) s (b) SPDF (c) SPD (d) SP (e) none apply

34. The electron configuration for the element with atomic number 20 is:
(a) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 3d^2$
(b) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 3d^1 4s^1$
(c) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2$
(d) answers (a) and (b) are equally correct.
(e) answers (b) and (c) are equally correct.

5. Chemical properties of an element are determined by:
(a) number of electrons in the outermost energy level.
(b) number of electrons in all energy levels.
(c) atomic number.
(d) number of protons.
(e) none of these apply.

The following tables refer to questions #16 - 19 inclusive:

Group A

At. No.	Symbol	Electron Configuration
3	Li	$1s^2\ 2s^1$
11	Na	$1s^2\ 2s^2\ 2p^6\ 3s^1$
19	K	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

Group B

At. No.	Symbol	Electron Configuration
3	Li	$1s^2\ 2s^1$
4	Be	$1s^2\ 2s^2$
5	B	$1s^2\ 2s^2\ 2p^1$
6	C	$1s^2\ 2s^2\ 2p^2$
7	N	$1s^2\ 2s^2\ 2p^3$
8	O	$1s^2\ 2s^2\ 2p^4$
9	F	$1s^2\ 2s^2\ 2p^5$

Group C

At. No.	Symbol	Electron Configuration
2	He	$1s^2$
10	Ne	$1s^2\ 2s^2\ 2p^6$
18	Ar	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
36	Kr	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3D^{10}\ 4s^2\ 4p^6$
54	Xe	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3D^{10}\ 4s^2\ 4p^6\ 4D^{10}\ 5s^2\ 5p^6$

36. In what manner would radii of element in group A behave?
   (a) as atomic number increases radii decrease because of the greater attraction between the nucleus and the electrons.
   (b) as atomic number increases radii increase due to the addition of energy levels.
   (c) as atomic number increase radii increases due to the shielding effect of electrons.
   (d) answers (a), (b), and (c) are equally correct.
   (e) only two of (a), (b), and (c) are equally correct.

37. In what manner would radii of element in group B behave?
   (a) as atomic number increases, atomic radii decrease due to increasing attraction between electrons and nucleus.
   (b) as atomic number increases, atomic radii increase due to the addition of electrons at the same energy level.
   (c) As atomic number increases, atomic radii increase due to the addition of electrons in orbitals s and p.
   (d) answers (a), (b), and (c) are equally correct.
   (e) none of the above apply.

38. Energy of ionization of elements in group A would tend to:
   (a) increase due to addition of energy level.
   (b) increase due to the greater attraction between the nucleus and the additional electrons.
   (c) decrease due to the addition of energy levels.
   (d) decrease due to the greater attraction between the nucleus and the electrons.
   (e) remains constant because of one electron in the s orbital.

139. Which group would best illustrate elements with similar properties?
(a) Group A (b) Group B (c) Group C (d) all three are equally correct
(e) only two of (a), (b), and (c) are correct

The following electronegativity chart refers to questions #20 - 22 inclusive.

H - 2.1	Fe - 1.8	Cu - 1.9
Be - 1.5	O - 3.5	Al - 1.5
Ca - 1.0	Cl - 3.0	S - 2.5
K - 0.8	Ba - 0.9	N - 3.0

40. The bond between H and S would be an example of:
(a) ionic bond (b) polar covalent (c) metallic (d) pure covalent
(e) Van der Waal

41. An example of an ionic bond would be:
(a) H and Cl (b) Al and S (c) S and O (d) Be and O
(e) none of the above apply

42. The elements Ca and Cl have the following outer electron configurations:
Ca - $4s^2$
Cl - $3s^2\ 3p^5$

The correct formula for the compound calcium chloride is:
(a) $CaCl_2$ (b) Ca_2Cl_4 (c) $CaCl$ (d) Ca_2Cl_5 (e) Ca_2Cl

3. The forces or bonds that hold a water moleculestogether thereby forming spherical droplets are called:
(a) ionic bonds (b) pure covalent (c) hydrogen bonds (d) Van der Waal
(e) metallic

UNIT VI

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

151. Given the formula $Ca_3(PO_4)_2$ and knowing that "Ca" has an ionic charge of +2, the charge for the "PO_4" radical is equivalent to:

(a) +6 (b) -6 (c) +3 (d) -3 (e) -2

152. Element "X" is found in Group II and element "Y" is found in Group VI of the Periodic Table. The likely formula for the compound would be:

(a) X_2Y_6 (b) XY (c) XY_3 (d) X_2Y_2 (e) X_3Y

153. The formula mass for the compound $Mg_2(PO_4)_3$ will be: (Atomic masses are Mg - 24, P - 31, O - 16)

(a) 71 (b) 143 (c) 371 (d) 119 (e) 333

154. The formula for magnesium hydride would be:

(a) MgH (b) MgOH (c) MgH_2 (d) $Mg(OH)_2$ (e) HMg

155. If carbon has an atomic weight of 12 grams, and a mole contains 6.02×10^{23} atoms, the number of atoms in 3 grams of carbon would be approximately:

(a) 6.02×10^{23} atoms (b) 18.06×10^{23} atoms (c) 3.01×10^{23} atoms
(d) 3.01×10^{19} atoms (e) 6.02×10^{19} atoms

156. Given the following data:

Element	Atomic Mass
A	12.0
B	19.0

A and B combine to form a new substance Y. If four moles of B atoms combine with one mole of A atoms to form one mole of Y, then the weight of one mole of Y is:

(a) 88 grams (b) 67 grams (c) 31 grams (d) 50 grams (e) 62 grams

157. Suppose twenty hydrogen molecules (H_2) and twenty oxygen molecules (O_2) are mixed and react chemically. The number of molecules formed would be:

(a) 20 (b) 10 (c) 40 (d) 30 (e) 80

158. Two moles of the compound $Al_2(SO_4)_3$ would contain how many moles of atoms:

(a) 17 (b) 10 (c) 5 (d) 34 (e) 68

159. The number of moles of water molecules in 72 grams of water are:

(a) 7.2 (b) 72 (c) 4 (d) 8 (e) 1

160. Phosphorus P_4, burns in air to form phosphorous pentoxide. The balanced equation for this chemical reaction is:

(a) $P_4 + 10\ O \longrightarrow 2P_2O_5$ (b) $P_4 + 10\ O_2 \longrightarrow 4PO_5$

(c) $P_4 + 5\ O_2 \longrightarrow 2P_2O_5$ (d) $P_4 + 20\ O \longrightarrow 4PO_5$

161. The following equation represents the combustion of the gas acetylene:

$$2C_2H_2 + 5\ O_2 \longrightarrow 4CO_2 + 2H_2O$$

The number of moles of oxygen required to burn 0.5 mole of acetylene would be:

(a) 1.5 moles (b) 1.25 moles (c) 2.5 moles (d) 5 moles
(e) none of the above answers are correct

162. For the above equation illustrating the burning of acetylene, the number of moles of carbon dioxide produced by burning 520 grams of acetylene would be: (atomic masses are carbon - 12, hydrogen - 1, oxygen - 16)

(a) 20 moles (b) 10 moles (c) 40 moles (d) 80 moles
(e) none of the above answers are correct.

163. Of the following statements about a chemical reaction, which of the following is correct:

(a) moles are conserved (b) mass is conserved (c) number of molecules are conserved (d) only one set of numbers can represent the proper ratio of reacting molecules

164. Given the chemical reaction for the production of ammonia gas:

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

If the nitrogen and hydrogen react completely to produce ammonia, the number of grams of ammonia produced from 1 mole of hydrogen would be: (atomic masses are: nitrogen - 14, hydrogen - 1)

(a) 17 (b) 34 (c) 11.3 (d) 22.6 (e) 25.5

165. Iron and oxygen may react in the following way:

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$

If one mole of iron and one mole of oxygen is available to react, the kind and quantity of the substance remaining after the reaction stops is:

(a) 0.75 mole of oxygen (b) 0.75 mole of iron (c) 0.25 mole of oxygen
(d) 0.25 mole of iron (e) 1.33 mole of iron

PHYSICAL SCIENCE - OBJECTIVE TEST

UNIT VII

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

171. A bunsen burner is applied for five minutes to the following quantities of water initially at room temperature:

(a) 100 ml (b) 200 ml (c) 300 ml (d) 400 ml

Which of the above quantities received the most heat:

(a) 1100 ml (b) 200 ml (c) 300 ml (d) 400 ml (e) all choices are equal.

172. Which of the choices of question #1 would show the highest temperature after the heat is applied?

(a) (b) (c) (d) (e)

173. In which of the choices of question #1 would the molecules of water be moving fastest:

(a) (b) (c) (d) (e)

174. 50 grams of water is heated from 20°C to 30°C. The amount of heat required is nearest to:

(a) 500 calories (b) 600 calories (c) 1,000 calories (d) 1,500 calories (e) 2,500 calories

75. 42 grams of water at 15°C is mixed with X grams of water at 90°C. The final temperature of the mixture is 60°C. The value of X is nearest to:

(a) 25 (b) 28 (c) 42 (d) 49 (e) 63

76. The amount of heat necessary to raise the temperature of 1 gram of water one degree centigrade is called:

(a) A British thermal unit.
(b) a celsius degree
(c) a caloric.
(d) a calorimeter
(e) a joule.

7. When 300 calories of heat is applied to 100 grams of goo, the temperature changes from 20°C to 30°C. The specific heat of goo is nearest to:

(a) 0.30 (b) 3.0 (c) 3.3 (d) 300 (e) 3000

8. The specific heats of two metals are as follows:

Alpha = 0.1 - Beta = 0.3

Equal weights of Alpha and Beta at 30°C are placed in an oven for the same length of time. The final temperature of Beta is 120°C. The final temperature of Alpha is nearest to:

(a) 60°C (b) 150°C (c) 270°C (d) 300°C (e) 360°C

179. 1500 calories of heat is applied to 10 grams of water initially at 30°C. The final temperature of the water is:

(a) 33°C (b) 80°C (c) 100°C (d) 150°C (e) 180°C

180. 0.2 moles of solid "Ringo Hydroxide" is placed in 100 cm^3 of water at 20°C (room temperature). After the hydroxide is dissolved, the temperature of the solution has raised to 30°C. The heat of solution of "Ringo Hydroxide" is nearest to:

(a) 5000 $\frac{\text{calories}}{\text{mole}}$ (b) 6000 $\frac{\text{calories}}{\text{mole}}$

(c) 1000 $\frac{\text{calories}}{\text{mole}}$ (d) 200 $\frac{\text{calories}}{\text{mole}}$

(e) 4000 $\frac{\text{calories}}{\text{mole}}$

181. One litre of pure air at 91°C is placed in an expandable container and then heated to 273°C. The new volume of air is:

(a) 0.33 litres (b) 0.67 litres (c) 1.0 litres (d) 1.5 litres (e) 3.0 litres

182. The temperature of a sample of gas is 27°C. If the average kinetic energy of the molecules is doubled, the new temperature of the gas is:

(a) 13.5°C (b) 54°C (c) 327°C (d) 371°C (e) 600°C

.83. The latent heat of fusion of water is 80 $\frac{\text{calories}}{\text{gram}}$. If 50 kilograms of water at 0°C is placed in a room, the number of calories released to the room when the water freezes is?

(a) 0 (b) 50 (c) 80 (d) 4,000 (e) 4,000,000

84. Which of the following cities would have the smallest annual temperature range:

(a) Vancouver (b) Banff (c) Regina (d) Brandon (e) Thunder Bay

35. 50 grams of metal at 100°C is placed in 30 grams of water or initially at 20°C. The final temperature of the mixture is 25°C. The amount of heat lost by the metal is:

(a) 75°C (b) 150°C (c) 75 calories (d) 150 calories (e) 3750 calories

36. The following gases are listed in increasing order of molecular mass.

(a) hydrogen (b) fluorene (c) nitrogen (d) oxygen (e) chlorine

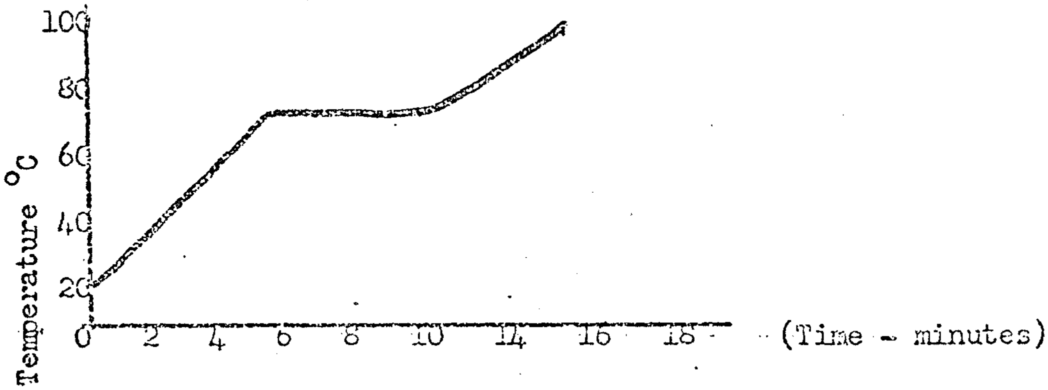
If the temperature of the gases is the same, the molecules of which of the above will have the highest average speed?

(a) (b) (c) (d) (e)

187. Styrofoam is a better insulator than wool because:

(a) It has a higher specific heat.
(b) It has a lower specific heat.
(c) It has a lower density.
(d) It's molecules are difficult to move.
(e) None of the above reasons.

Information for questions 18 through 20: Heat from a burner which supplies 1000 calories/minute is appled to 200 grams of solid plastic. A graph of temperature vs. time is shown below:



88. The melting point of this plastic is:

(a) 20° (b) 40° (c) 60° (d) 80° (e) 100°

89. The number of calories of heat required for the melting process only is:

(a) 6000 (b) 8000 (c) 10,000 (d) 12,000 (e) 16,000

90. The specific heat of the solid plastic is nearest to:

(a) 0.1 (b) 0.3 (c) 0.5 (d) 0.7 (e) 0.9

91. Heat energy needed to change the state of a substance is called:

(a) latent heat (b) early heat (c) heat of transformation
(d) heat of liquifaction (e) heat of solidification

92. Hydrogen, helium, nitrogen and oxygen, are each used to inflate a balloon to the same volume in a cool room. The four balloons are then placed in the hot sun. The largest balloon at the end of one hour will be the one filled with:

(a) hydrogen (b) helium (c) nitrogen (d) oxygen (e) all will be the same size

3. A thermometer calibrated in the Kelvin Scale when placed in boiling water would read:

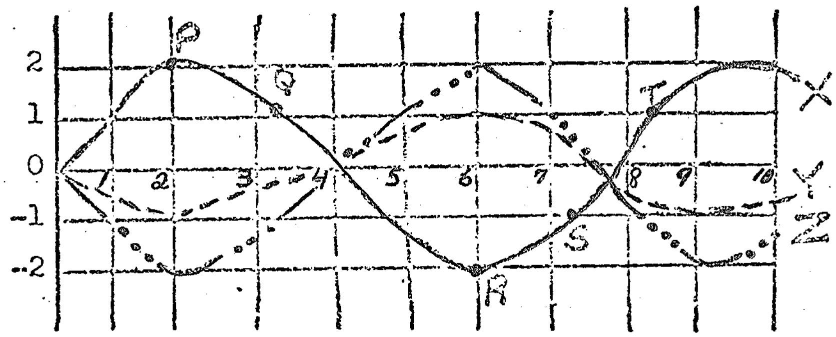
(a) 473° (b) 373° (c) 273° (d) 173° (e) 73°

PHYSICAL SCIENCE 201 - OBJECTIVE TEST

UNIT VIII

Directions: Indicate your answers of the answer sheet by shading in the areas between the narrow vertical lines beside each question.

Wave Forms X, Y, and Z



11. The amplitude of wave X is:

(a) 8 cm (b) 4 cm (c) 2 cm (d) 0 cm (e) -4 cm

12. Which of the choices of question #11 describe the wave length of wave X?

13. Which of the wave forms are in phase:

(a) X and Y (b) X and Z (c) Y and Z (d) X, Y, and Z
(e) all are out of phase

14. Wave form X is moving to the right. Point P is moving:

(a) up (b) down (c) right (d) left (e) is not moving

15. Which of the choices of question #14 describes the motion of point Q?

16. Which of the following points on Wave X is located on a crest?

(a) P (b) Q (c) R (d) S (e) T

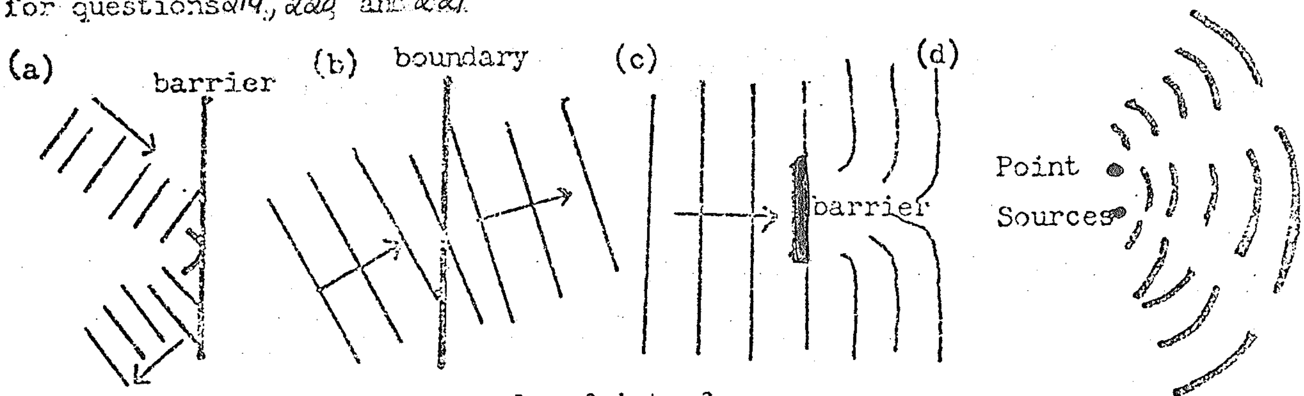
17. The frequency of wave X is 10 cycles. The speed at which the wave is moving is:

(a) 0.8 cm/sec. (b) 20 cm/sec. (c) 40 cm/sec. (d) 80 cm/sec.
(e) none of these choices

18. Which combination of pulses as shown above cancel each other completely:

(a) X and Y (b) X and Z (c) Y and Z (d) X, Y and Z
(e) no cancellation can occur.

The diagrams below show various waves in a ripple tank. Use diagrams for questions 219, 220 and 221



19. Which of the above is an example of interference:

(a) (b) (c) (d) (e) none of the above

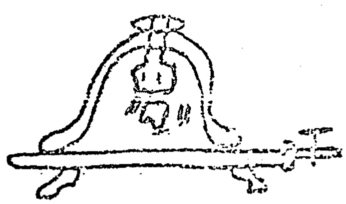
20. Which of the above is an example of refraction:

(a) (b) (c) (d) (e) none of the above

21. Which of the above is an example of diffraction:

(a) (b) (c) (d) (e) none of the above

22.



When air is allowed to enter the bell jar the ringing of the electric bell is easily heard. When the air is pumped out of the jar the ringing of the bell cannot be easily heard. Which of the following reasons best explains this phenomena:

(a) sound will travel through air only.
(b) sound will travel through a vacuum only.
(c) matter must be present for transmission of sound.
(d) light can be transmitted through a vacuum.
(e) sound requires a vibrating object.

3. Two sound waves in air of equal amplitude and wavelength may differ in:

(a) pitch (b) loudness (c) quality (d) frequency (e) none of these

4. The highest sound frequency detectable by the human ear is about:

(a) 20 cycles/sec. (b) 200 cycles/sec. (c) 2,000 cycles/sec.
(d) 20,000 cycles/sec. (e) 200,000 cycles/sec.

. The part of the ear that converts sound waves to nerve impulses is:

(a) cochlea (b) auditory nerve (c) oval window (d) semicircular canals
(e) ear drum

. A lampshade vibrates in response to a certain musical tone. This phenomenon is known as:

(a) beats (b) forced vibrations (c) overtones (d) resonance
(e) mach number

227. The shortest length of a tube closed at one end that amplifies the sound of a tuning fork is:

(a) 1/4 λ (b) 1/2 λ (c) 2λ (d) λ (e) 4λ

228. As a fast moving car passes you while sounding its horn, a change of pitch is detected. This phenomenon is known as:

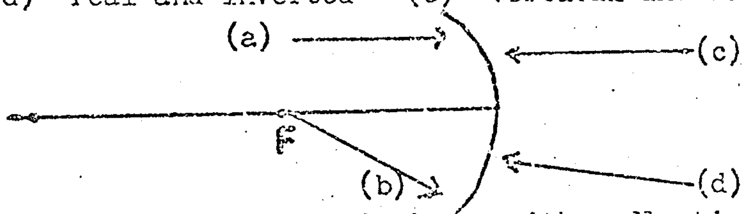
(a) resonance (b) sympathetic vibrations (c) the harmonic effect
(d) enterference (e) the Doppler effect

229. The index of refraction of glass is independent of:

(a) angle of incidence (b) color (c) frequency (d) wavelength
(e) period

230. Which of the following terms best describes the image in a plance mirror:

(a) vertical and erect (b) vertical and inverted (c) real and erect
(d) real and inverted (e) vertical and real



(e) none of the above

Shown above is a curved mirror with reflecting surfaces on both sides. Which incident ray in the diagram would reflect through the focus F?

(a) (b) (c) (d) (e)

232. An object is 20 cm. in front of a concavermirror which has a focal length of 12 cm. The distance from the image to mirror is:

(a) 5.3 cm (b) 7.2 cm (c) 18 cm (d) 19.2 cm (e) 30 cm

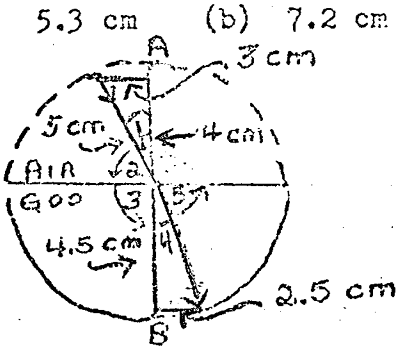


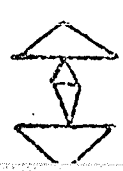
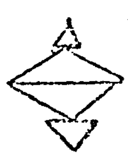
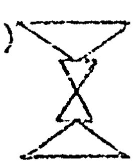
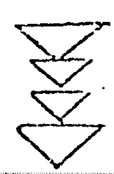
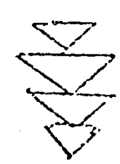
Diagram of a light ray travelling from air to goo in a semi-circular dish. AB is a perpendicular through the center of the circle O. The index of refraction of goo is:

(a) 0.83 (b) 0.93 (c) 1 (d) 1.08 (e) 1.2

Which of the numbered angles in the diagram of question #232 is the angle of refraction:

(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

Which of the following arrangements of prisms will form the best converging lens?

(a)  (b)  (c)  (d)  (e) 

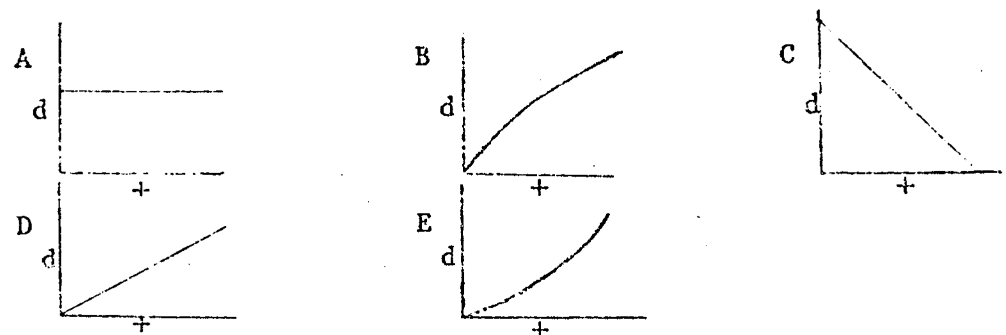
MECHANICS

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

1. From the following list, select the one that is a scalar quantity.

   (a) force (b) mass (c) displacement
   (b) acceleration (e) velocity

2. A steel ball bearing rolls with a constant speed in a positive direction. If you plot distance versus time, your graph will be closest to which of the following?



3. The change of distance per unit of time with reference to direction is called:

   (a) velocity (b) speed (c) inertia (d) acceleration
   (e) distance

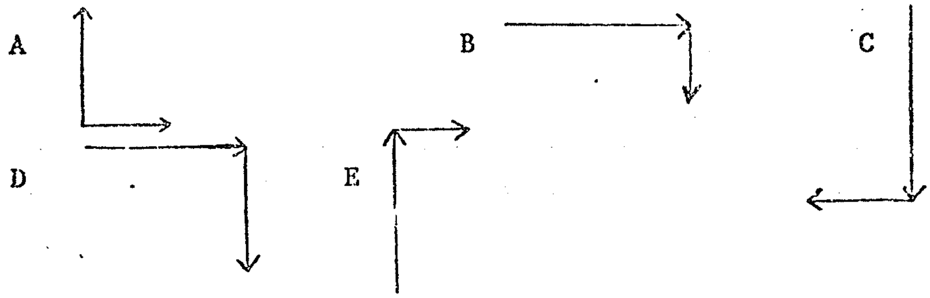
4. Accelerations are <u>never</u> expressed as:

   (a) miles per hour per second
   (b) meters per second squared
   (c) feet per second
   (d) cm/sec^2
   (e) the time rate of change of velocity

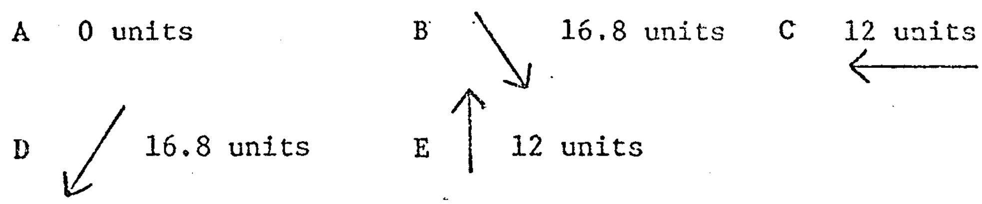
5. Which of the following ratios defines acceleration?

   (a) distance/time (b) mass/force
   (b) resistance/effort (d) velocity/time
   (c) mass/velocity

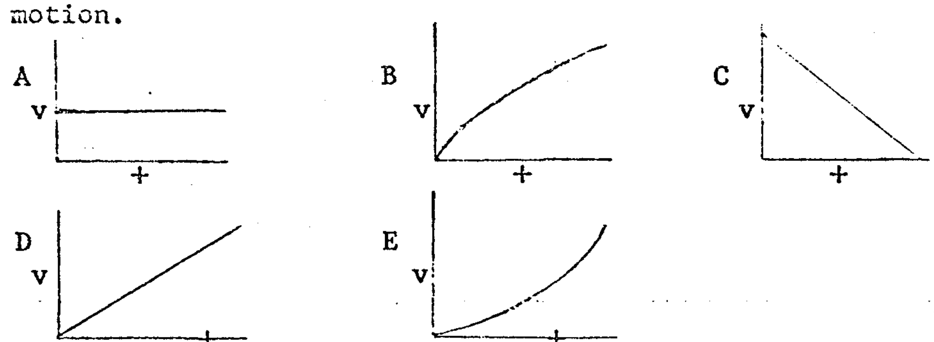
6. A student wants to add two vectors representing a displacement of 10 meters north and 5 meters east. Which of the answers below represents the proper vector addition?



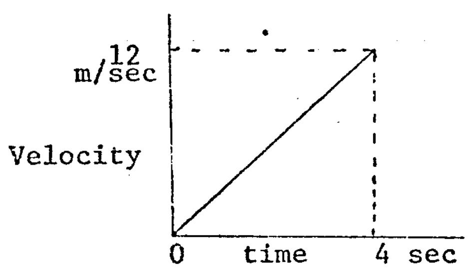
7. A student subtracts two vectors. One vector is 12 units long and points east. The other vector is also 12 units long but points south. Which of the following answers represents the resultant vector?



8. A steel ball rolls up an incline plane and deccelerates at a constant rate. Which of the following velocity-time graphs illustrate this motion.



9. What is the rate of acceleration illustrated by the following graph?



a) 12 m/sec^2 b) zero c) 3 m/sec^2
d) variable and cannot be determined e) 48 m/sec^2

The following statement will be used for the next three questions. A car starts from rest and receives a uniform westward acceleration of 4 feet per second per second.

10. What is the westward velocity of the car in feet per second at the end of the third second of acceleration?

a) 6 b) 12 c) 36 d) 4 e) 18

11. What is the average westward velocity of the car in feet per second during the first three seconds of acceleration?

a) 6 b) 12 c) 36 d) 4 e) 18

12. How far westward in feet does the car travel during the first three seconds of acceleration?

a) 6 b) 12 c) 36 d) 4 e) 18

13. Which of the following is <u>not</u> a description of force?

a) The product of mass and acceleration
b) A push or a pull
c) A measure of an object's weight
d) A vector quantity
e) A measure of an object's inertia

14. If a horizontal force F causes a mass M to accelerate at rate A horizontally, the mass 2M will accelerate with the same force at rate.

a) 1/2 A b) A c) 2A d) 32A e) 9.8A

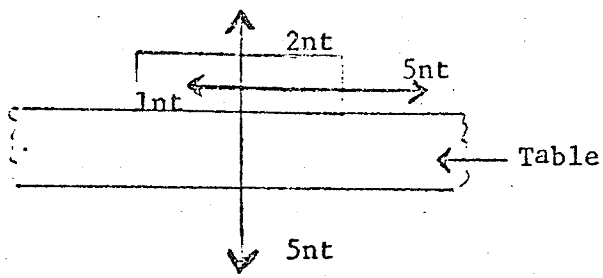
15. Newtons second law of motion states that when mass is in kilograms and acceleration is in meters/second squared, force is in:

a) dynes b) poundals c) kilograms d) joules e) newtons

16. The resultant between two forces, at a point, acting at right angles to each other:

a) is always less than one of the forces
b) is the average of the forces
c) always bisects the angle between the lines of action of the forces
d) must be greater than either of the forces
e) may be equal to one of the forces

(This description relates to the next two questions)
A block resting on a table is acted upon by the forces shown in the diagram where the downward force is due to the weight of the body.



17. The force available to accelerate the body to the right is:

a) 4nt b) 5nt c) 7nt d) 13nt e) none of these

18. The resultant for all the forces in the diagram is:

a) 4nt b) 5nt c) 7nt d) 13nt 3) none of these

19. Which of the following statements illustrates newton's third law of motion?

a) The heavier cars must have more powerful engines if they are to have "pick-up" (acceleration) equal to lighter cars.

b) When one shoots a gun, he must be careful not to be hurt by the recoil of the gun.

c) If all the forces acting on a moving car could be removed, the car would continue to move at a constant velocity.

d) A ball rolling down a frictionless incline plane accelerates at a constant rate.

e) A satellite travels at a constant speed in a circular orbit orbit around the earth.

20. Mass differs from weight in that:

a) All objects have weight but some lack mass

b) Weight cannot be expressed in the metric system

c) The mass of an object always exceeds its weight

d) Weight is a force, mass is not

e) None of the above; there is no difference

21. If the earth were twice its present diameter and double its present mass, a boy now weighing 500nt would weight:

a) 500nt b) 125nt c) 250nt d) 1000nt e) 4000nt

NOTE:

$$F = \frac{KMm}{d^2}$$

22. In which of the following situations is work being done?

a) Lifting half-dollar through a height of one meter

b) A body sliding along a frictionless horizontal plane

c) A man holding a suitcase off the ground while waiting for a bus

d) A man, pushing with all his strength, is just able to stop a car from rolling down a hill

e) Two teams of equal strength pull on opposite ends of a rope

23. Work is measured using

a) Newton-meters

b) Weight of an object times the vertical height moved?

c) Joules

d) The change in energy of a body

e) All of the above

24. Energy may be defined as the capacity for

a) Exerting force

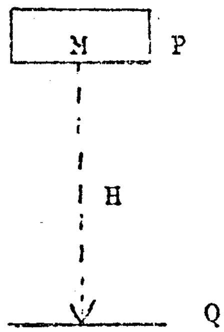
b) Action

c) Great power

d) Doing work

e) Producing motion

25. The mass, M, at point P falls a distance "h" to Q. Which of the following are equal?



a) The kinetic energy at Q and the potential energy at P

b) mgh and 1/2 mv^2

c) The kinetic energy at Q and the work required to left M from Q to P

d) The potential energy at P and the work required to left M from Q to P

e) All of the above

26. The fact that a swinging pendulum eventually comes to rest is not a violation of the law of conservation of energy because energy may be:

a) Created but not destroyed

b) Destroyed but not created

c) Created and destroyed but not transferred from one form into another

d) Changed from one form to another but neither created nor destroyed

27. When an object falls from a position 300 meters high its energy:

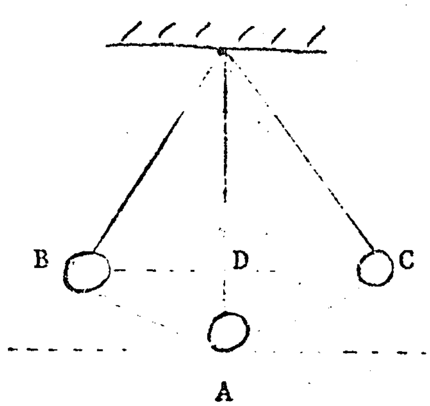
a) Increases during its fall

b) Decreases during its fall

c) Remains constant during its fall

d) Is zero at the start of the fall

e) Is a maximum at the end of the fall.

28. 

In order to determine the work done in moving the pendulum from its lowest to its highest position in an oscillation you would need to know the force and distance:

a) AB b) AC c) BD d) DC e) AD

29. Power may be expressed as:

a) Work done/elapsed time

b) Joules/sec

c) Energy used/elapsed time

d) nt-m/sec

e) All of the above

CHEMICAL KINETICS

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

41. When two atoms react to form an ionic compound, we assume in accordance with the atomic theory that:

    (a) one or more pairs of electrons are shared in common between the two atoms.
    (b) one or more electrons are transferred from one atom to the other.
    (c) the atoms are held together by the electrostatic force between protons and neutrons.
    (d) the atoms are held together by the force of gravity.

42. Aluminum has an oxidation number of +3 and oxygen has an oxidation number of -2.

    (a) Oxygen is more electropositive than aluminum.
    (b) The formula for aluminum oxide would be Al_3O_2.
    (c) Aluminum is more electronegative than oxygen.
    (d) The formula for aluminum oxide should be Al_2O_3.
    (e) All of the above.

43. The neutralization of an acid by a base always produces:

    (a) soluble products.
    (b) a precipitate.
    (c) a gas.
    (d) sodium chloride.
    (e) water.

44. For a reaction to take place it is necessary that

    (a) the molecules be in the form of a gas.
    (b) the substance must be under a high pressure.
    (c) a force of attraction exist between the molecules.
    (d) the molecules collide.
    (e) the molecules move at their maximum speed.

45. The most likely reason why an increase of temperature will increase the rate of a chemical reaction is that

(a) an increase of temperature increases the valence of the reacting substances.
(b) an increase of temperature increases the kinetic energy of the reacting molecules.
(c) higher temperatures eliminate the products of a reaction.
(d) heat acts as a catalyst.
(e) an increase of temperature increases the time that the reacting molecules are in contact during any one collision.

46. Potassium chlorate decomposes giving oxygen gas and potassium chloride. The correct equation is:

(a) $2KClO_3 \rightarrow 2KCl + 3O_2$

(b) $KClO_3 \rightarrow KCl + 2O_2$

(c) $2KClO_3 \rightarrow 2KCl + 2O_3$

(d) $KClO_3 \rightarrow KCl + O_3$

(e) $KCl(O_3)_2 \rightarrow KCl + 3O_2$

47. When octane (C_8H_{18}) burns, the products are carbon dioxide and water. The correct chemical equation is:

(a) $C_8H_{18(g)} + 9O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(g)}$

(b) $C_8H_{18(g)} + 4.5O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(g)}$

(c) $C_8H_{18(g)} + 9O_{(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(g)}$

(d) $2C_8H_{18(g)} + 25O_{2(g)} \rightarrow 16\ CO_{2(g)} + 18H_2O_{(g)}$

(e) $C_8H_{18(g)} + 12.5O_{2(g)} \rightarrow 8CO_{2(g)} + 4.5H_2O_{(g)}$

48. If heat energy is given off during an ordinary chemical reaction,

(a) it is called activation energy.
(b) the reaction is exothermic.
(c) it is called atomic energy.
(d) it will always start spontaneously.
(e) the product formed will be very unstable.

49. The neutralization of an acid by a base always produces:

(a) soluble products.
(b) a precipitate.
(c) a gas.
(d) sodium chloride.
(e) water.

The following factors influence the velocity of chemical reactions, causing a reaction to take place more rapidly or more slowly. After each item blacken the corresponding space on the answer sheet if:

(a) the factor is change in temperature.
(b) the factor is change in concentration of the reactants.
(c) the factor is alteration in size of particles, or change in total surface exposed.
(d) the factor is a catalyst (positive or negative)
(e) the factor is the nature of the substance (reactive or non-reactive).

The next eight questions refer to the above statements.

50. Very finely powdered pure iron will ignite when thrown out into the air.

51. A glowing splint burns faster when placed in a bottle of pure oxygen.

52. Dirigibles and other lighter-than-air craft are much safer when filled with helium.

53. Acetanilide is used to inhibit the decomposition of hydrogen peroxide.

54. Magnesium reacts very slowly with water, while sodium reacts much more rapidly.

55. Hydrogen peroxide rapidly decomposes into water and oxygen when a small amount of powdered manganese dioxide is added.

56. Many chemical reactions occurring in water solutions can be made to proceed more slowly be adding water.

57. When molecules move faster, collisions occur more frequently, thus increasing opportunities for reaction.

58. The point of equilibrium in a chemical reaction is dependent upon:

(a) the state of subdivision of the reactants.
(b) the temperature at which the reaction takes place.
(c) the prescence or absence of a catalyst.
(d) the time to reach a state of equilibrium.
(e) none of the above.

59. A few drops of sodium acetate (Na C_2 H_3 O_2) is added to the following equilibrium system.

$$HC_2H_3O_2 + H_2O \rightleftarrows H_3O^+ + C_2H_3O_2^-$$

The addition of sodium acetate produces:

(a) a decrease in the concentration of $C_2H_3O_2^-$

(b) a decrease in the concentration of H_2O

(c) an increase in the concentration of $HC_2H_3O_2$

(d) no change

(e) a stronger acidic solution

60. The principle of Le Chatelier

(a) says that when a system in equilibrium is subject to strain, the stress will move in the direction of equilibrium.
(b) accounts for the speeding up of chemical reactions at high temperatures.
(c) says that stress must equal strain.
(d) explains why high pressures are used in industrial synthesis of ammonia.
(e) explains why high temperatures alone will not liquify air.

61. Given $2NH_{3(g)}$ + 22 k.cal. $\rightleftarrows$ $N_{2(g)}$ + $3H_{2(g)}$ (endothermic) which of the following best describes what happens when heat energy is added to the system?

(a) Amount of NH_3 would increase.
(b) Amount of N_2 would decrease.
(c) Amount of N_2 and H_2 would increase.
(d) Amount of H_2 would increase.
(e) Amount of N_2 and H_2 would decrease.

62. The system containing CO_2 (carbon dioxide) and H_2CO_3 (carbonic acid) in a water solution is said to be in a state of equilibrium when

(a) the solution will not affect litmus.
(b) the amounts of CO_2, H_2O and H_2CO_3 are equal.
(c) the H_2CO_3 is forming and decomposing at equal rates.
(d) the amounts of CO_2, H_2O and H_2CO_3 are proportional to their molecular weights.
(e) a minimum number of ions remains in the solution.

63. A substance is said to be basic if it

(a) contains H^+ ions.
(b) tastes sour.
(c) turns litmus red.
(d) contains free protons.
(e) contains hydroxyl ions.

64. An acid or a base is said to be active or strong if it

(a) is highly concentrated.
(b) is in a state of equilibrium.
(c) attacks steel rapidly.
(d) is highly dissociated.
(e) is highly hydrated.

65. An indicator is a substance,

(a) which always changes color when the solution passes through that hydronium ion concentration at which the pH is 7.
(b) in which the positive and negative ions have a different color.
(c) which under no conditions is colourless.
(d) which is used to detect whether the solution contains an excess of positive or of negative ions.
(e) which changes color when passing through a definite pH range characteristic of that indicator.

66. An aqueous solution of ammonia

(a) has a pH of less than 7 because the ammonia molecule picks up protons from the water.
(b) provides a low concentration of hydroxyl ions and is therefore useful for cleaning purposes.
(c) is almost completely ionized into ammonium and hydroxyl ions.
(d) has its hydroxyl ion concentration increased by the addition of ammonium chloride.
(e) is the only form of nitrogen that plants can assimilate.

67. Which of the following is not true?

(a) The pH is a measure of hydronium ion concentration.
(b) A solution of pH10 is basic.
(c) A solution of pH8 is acidic.
(d) The hydroxide ion concentration multiplied by the hydronium ion concentration is equal to a constant number.
(e) The hydronium ion concentration is equal to the hydroxide ion in pure water.

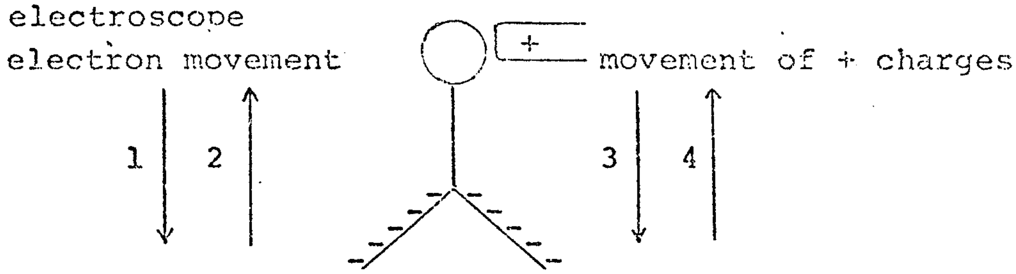
ELECTRICITY

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

121. Two pith balls, both of which have been touched by a hard rubber rod which had been rubbed with wool, will:

(a) attract each other and be repelled by the rod
(b) repel each other and be attracted by the rod
(c) repel each other and be repelled by the rod
(d) attract each other and be attracted by the rod
(e) attract each other and be repelled by a glass rod which has been rubbed with silk

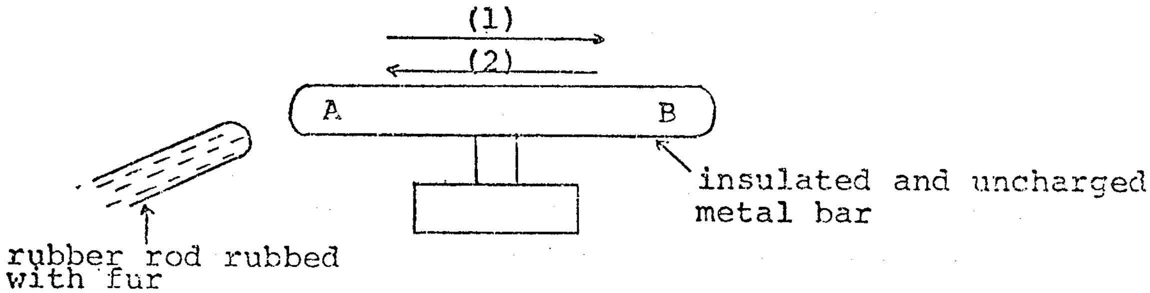
122. A positively charged glass rod is brought near to but does not touch, the knob of a negatively charged electroscope



(a) the leaves collapse from motion (3)
(b) the leaves diverge farther from motion (4)
(c) the leaves diverge farther from motion (1)
(d) the leaves collapse from motion (2)

123. A conductor of electricity is a material

(a) which contains more electrons than protons
(b) which is solid except at very high temperatures
(c) which is opaque to visible light
(d) whose electrons are all on the surface
(e) through which electrons move freely



The above diagram is used in the next three questions.

124. As the result of the prescence of the rod near the bar:

(a) negative charges move in direction (1)
(b) negative charges move in direction (2)
(c) positive charges move in direction (1)
(d) positive charges move in direction (2)
(e) both positive and negative charges move in opposite directions

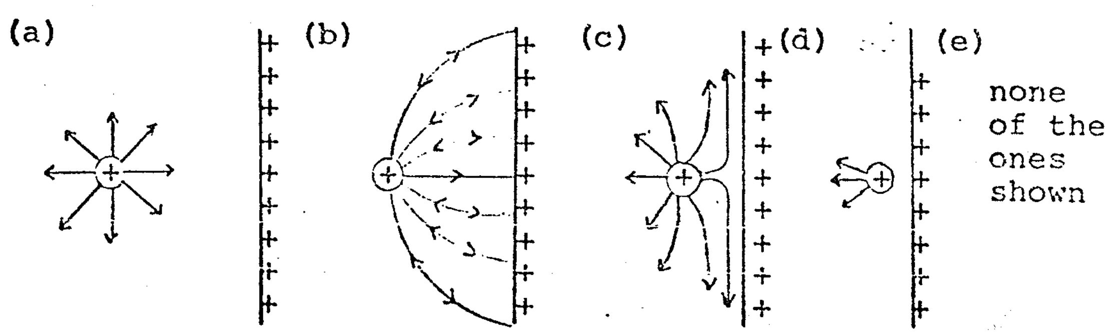
125. As a result of the prescence of the rod near the bar, the bar is

(a) - at end A and - at end B
(b) - at end A and + at end B
(c) + at end A and - at end B
(d) + at end A and + at end B
(e) entirely neutral

126. With the charged rod still in position a finger is placed on the metal bar and grounds it. The charged rod is then removed.

(a) the metal bar is positively charged
(b) the metal bar is negatively charged
(c) the metal bar is neutral
(d) end A is positive, end B is negative
(e) end A is negative, end B is positive

127. Which of the diagrams below represents the most likely electrical field between a point and a flat surface both of which are positively charged?



128. The statement that one joule of work is required to move a charge of one coulomb from one point to another is a definition of:

(a) a watt (b) an ohm (c) an ampere
(d) an oersted (e) a volt

129. Which of the following is <u>not</u> a source of continuous current?

(a) a car battery
(b) a photoelectric cell in a camera
(c) a bike generator used to produce a light
(d) a copper and iron wire are joined together at one end. At the other ends copper is in hot water and iron is in cold water
(e) a rubber rod is rubbed with wool and then touches an electroscope

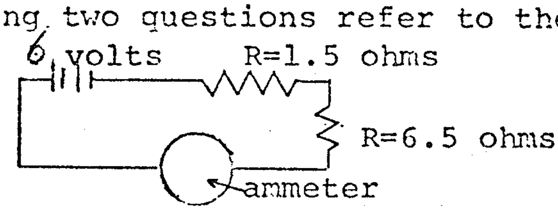
130. Ohm's law states that the current varies directly with the:

(a) resistance and inversely with the voltage
(b) voltage and inversely with the resistance
(c) resistance and inversely with the potential
(d) voltage and inversely as the square of the distance
(e) none of the above

131. An electrical appliance whose resistance is 200 ohms draws a current of one-half ampere. The voltage applied is, in volts:

(a) 0.40 (b) 40 (c) 50 (d) 100
(e) 200

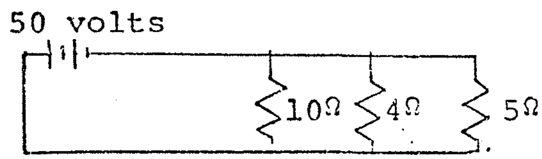
The following two questions refer to the diagram below.



132. The ammeter in the diagram above will read:
(a) .25 amperes (b) .75 amperes
(c) 1.5 amperes (d) 2.0 amperes
(e) none of these

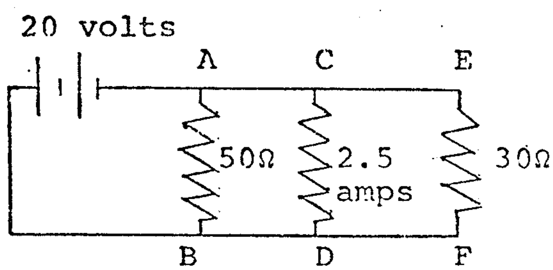
133. If a current of 4 amperes were flowing through the circuit in the diagram, the power produced in the 1.5 ohm resistance would be

(a) 4.5 watts (b) 2 watts
(c) 24 watts (d) 9 watts
(e) 0.25 watts



134. The total resistance of the circuit will be:

(a) $\frac{20}{11}$ ohms (b) 19 ohms
(c) $\frac{11}{20}$ ohms (d) 200 ohms
(e) 220 ohms



The following three questions refer to the above diagram.

135. What is the voltage across the resistor AB?

(a) 2 volts (b) 100 volts
(c) 1000 volts (d) 20 volts
(e) 2.5 volts

136. What is the resistance of resistor CD?

(a) 8 ohms (b) 50 ohms
(c) .25 ohms (d) 20 ohms
(e) 2.5 ohms

137. What is the current in the resistor EF?

(a) 600 amperes (b) 2/3 ampere
(c) 1.5 amperes (d) 30 amperes
(e) 50 amperes

138. When an electric current flows through a resistance the energy is expended as:

(a) chemical energy (b) amperes
(c) volts (d) sound
(e) heat

139. The quantity of heat developed per minute in a coil of fixed resistance is:

(a) proportional to the current in the coil
(b) proportional to the square of the current in the coil
(c) proportional to the square of the resistance of the coil
(d) inversely proportional to the current in the coil
(e) proportional to the potential difference at the terminals of the coil

140. A heater element is rated to pass 5 amperes when connected to a 120 volt line. In operation the element loses heat at a rate of

(a) 5 joules/sec. (b) 24 joules/sec.
(c) 120 joules/sec. (d) 600 joules/sec.
(e) 3,000 joules/sec.

141. The unit of electrical power is the watt. Which of the following is correct?

(a) watts = amperes/volts
(b) watts = ohms/volts
(c) watts = volts x amperes
(d) watts = ohms x amperes
(e) watts = wolts x ohms

142. A conductor consisting of a straight rod cuts a magnetic field. Which one of the following statements is false?

(a) the faster the motion of the rod, the greater the induced voltage
(b) a continuous current flows from one end of the rod to the other
(c) the stronger the magnet, the greater the induced voltage at any given rate of cutting lines of force
(d) the effect is the same whether the magnet is a permanent magnet or an electromagnet
(e) none of the above

143. An induction coil will not operate when the current in the primary coil is:

(a) changing
(b) increasing
(c) decreasing
(d) constant
(e) alternating

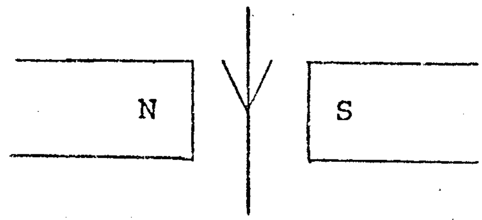
144. A transformer may be used:

(a) to convert an alternating current and voltage to a larger current at higher voltage
(b) to transform alternating current to direct current
(c) to decrease an alternating voltage and to increase the current
(d) to step up the voltage of a battery
(e) to transform an alternating current at one frequency to an alternating current at another frequency

145. A magnetic field exerts a force upon an electric charge only when the charge is

(a) at rest, the field stationary
(b) moving in the direction of the field
(c) moving against the direction of the field
(d) moving across the field

146. If a current flows in the wire between the poles of a magnet as shown in the diagram, the wire moves:



(a) to the right
(b) to the left
(c) toward the reader
(d) away from the reader
(e) upward

147. A coulomb is an electrical unit which measures:

(a) the total number of electrons in an object
(b) the total number of positive charges in an object
(c) the excess or deficiency of electrons in an object
(d) the number of objects charged
(e) all of the above

148. The electric current in a wire usually consists of:

(a) positive ions in motion
(b) negative ions in motion
(c) atomic nuclei in motion
(d) electrons in motion
(e) molecules in motion

149. If one were to compare electricity with water, the ampere would come the nearest to representing a measure of:

(a) the rate of flow of water, for example, 10 cubic feet per second
(b) the pressure of water in a pipe, for example, 10 pounds per square inch
(c) the work the water can do in rotating a turbine
(d) the quantity of water, for example, 10 cubic feet
(e) the density of water, for example, pounds per cubic foot

ELECTROCHEMISTRY

Directions: Indicate your answers on the answer sheet by shading in the areas between the narrow vertical lines beside each question.

81. Copper, silver and gold were the first metals to be refined by man because:

    (a) they were the shiniest and therefore easiest to find.
    (b) their melting point was lower than any other metal.
    (c) they are the most reactive of metals.
    (d) they are the most easily obtained from their oxides.
    (e) they react most quickly with oxygen.

82. In the reactivity series of metals the uppermost group of metals

    (a) are the least reactive.
    (b) do not displace hydrogen from water.
    (c) do not displace hydrogen from an acid.
    (d) do not react with oxygen.
    (e) are too reactive to risk placing in an acid.

83. Which group of metals would be the lowest on a reactivity scale?

    (a) Potassium, sodium, lithium.
    (b) Silver, gold, platinum.
    (c) Iron, tin, lead.
    (d) Aluminum, magnesium, calcium.
    (e) Mercury, copper, lead.

84. An iron nail is placed in a copper sulfate solution. Soon the nail becomes coated with a copper coloured substance and the solution loses its deep blue color. The reaction has occurred because:

(a) iron has displaced the copper.
(b) copper is higher on the reactivity series than iron.
(c) copper has displaced the iron in the nail.
(d) copper gives off electrons more easily than iron.
(e) the sulfate has left the solution and has solidified on the nail.

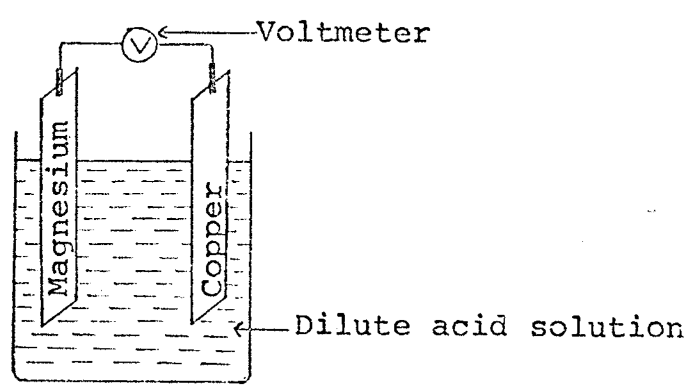
85. The reactivity series

(a) explains which metals were discovered first.
(b) illustrates which metals are most dense.
(c) explains why some reactions with metals occur and others do not.
(d) can be used to determine which atoms have the largest volume.
(e) shows that any metal can displace the one above from one of its compounds.

86. Lithium can become a positive ion more easily than Aluminum because:

(a) it has a smaller nuclear charge.
(b) it is less electronegative.
(c) it has a smaller atomic volume.
(d) it sheds less electrons.
(e) all of the above.

- This diagram refers to the next three questions.



A strip of magnesium metal and a strip of copper metal were placed in a dilute acid solution and connected to a voltmeter.

87. Magnesium has a voltage number of +2.34, hydrogen has a voltage number of 0, and copper has a voltage number of -0.34. If copper and magnesium are placed in a dilute acid solution the voltage of the resulting cell will be:

(a) 2.68 volts
(b) 5.36 volts
(c) 2 volts
(d) 4 volts
(e) 0 volts

88. If magnesium is higher on the reactivity series than copper:

(a) the electrons should flow from left to right since magnesium gives off electrons with a greater pressure than copper.
(b) there is no electron flow through the wire since the voltmeter is attached.
(c) electrons would flow and both plates would disappear even if the wire is cut.
(d) the electrons will flow from right to left since copper gives off electrons with a greater pressure than magnesium.
(e) the electrons will flow from a region of lower pressure to a region of higher pressure.

89. The dilute acid solution:

(a) will contain no magnesium or copper ions.
(b) will contain equal amounts of magnesium and copper ions.
(c) will contain more magnesium than copper ions.
(d) will contain more copper than magnesium ions.
(e) will contain only electrons.

\- The following list of batteries are commonly used today.

(a) lead batteries.
(b) alkaline batteries.
(c) nickel cadimum batteries.
(d) modern Leclanche or dry cell.
(e) zinc mercury cell.

Select the battery or cell which would be used in the following circumstances.

Leaf blank to correct numbering.

90. Used in a pacemakers to regulate heartbeat.

91. Used in cars for starting the motor.

92. Used in flashlights.

93. Iron in the prescence of water tends to shed electrons and change to iron ions. This process is known as:

(a) de-electronation.
(b) oxidation.
(c) corrosion.
(d) rusting.
(e) all of the above.

94. Bags of magnesium are connected to the inside of an iron ship by a conductor. This prevents the ship from rusting:

(a) because the magnesium absorbs moisture from the iron.
(b) by allowing iron ions to form more easily.
(c) because iron gives off electrons to magnesium.
(d) by allowing iron ixode to form more quickly.
(e) because the magnesium forces negative charges on the iron.

95. Anodising is the process whereby:

(a) metals are coated with grease to prevent corrosion.
(b) metals are plated with another metal lower down the reactivity series to prevent corrosion.
(c) metals are coated with a thick oxide layer to prevent corrosion.
(d) metals are provided with electrons to prevent corrosion.
(e) all of the above.

96. Two iron nails are placed in a solution of copper sulfate and connected to a battery.

(a) The nail connected to the positive battery terminal becomes coated with copper.
(b) The nail connected to the negative battery terminal gives off a gas.
(c) The copper sulfate solution turns red.
(d) The nail connected to the negative terminal of the battery becomes coated with copper.
(e) Sulfur will deposit on the nail connected to the negative electrode on the battery.