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ABSTRACT

The absence of suitable instruments to measure scientific inquiry skills, and the inability of teachers to construct their own tests to measure mastery of science skills led the Peterborough County (Ontario) Board of Education to develop skill-oriented curriculum guidelines in response to changes in Ministry of Education priorities in science. Skills of scientific inquiry were identified, levels of student growth for each skill were described, and a pool of test items with a teachers' manual was developed. The primary impact of the project is to give teachers a practical tool that will provide them with feedback on student skill development and the effects of the science program. The project is also to promote a generalizable approach to curriculum development. Successful completion of the project will increase curricular skills of the participants, and dissemination of the products will heighten support for this approach to curricular innovation. (Author/GK)

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Experimental Problem Solving Item Pool

Junior and Intermediate Division Science

Project #80-4029 Final R & D Report to the
Ontario Institute For Studies In Education

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1. Abstract

Seven skills of scientific inquiry were identified from Ontario Ministry guidelines. These skills were given multi-levelled behavioural definitions. Separate test item pools were constructed for the junior and intermediate divisions using inquiry situations derived from the curriculum guidelines of one school system. The item pools were field tested and substantially revised.

2. Project Description

In the last ten years there has been a significant shift in priorities within the science curriculum toward a greater emphasis on developing student skills in fundamental science processes. This shift is reflected in circular P1J1 and in the Senior Science Guidelines as well as in locally developed curriculum materials.

Discussion with teachers of the current state of evaluation practices with respect to the new emphasis on science inquiry skills has revealed that teachers feel competent to produce test items to measure science content but feel that they lack the knowledge and skill required to produce tests to measure science inquiry skills. In addition teachers are unaware of any existing assessment tools which could be used to measure these higher order cognitive objectives in science. The lack of such tools has aroused concern that if these skills are not measured they are less likely to be taught. Furthermore there is concern that if there is no valid and reliable means to assess student growth in science skills it is inordinately difficult for the teacher to key instruction to the appropriate level of student development.

Existing Science Assessment Tools

In a review of available commercial measures Wahlstrom et al (1977) concluded that Ministry of Education Science objectives are consistently assessed only by the Stanford Early Achievement Tests. Examination of these tests reveals that the items focus on understanding basic science concepts--on knowing the products of science not on mastering the processes of science. Mastery of the requisite skills of scientific inquiry cannot be determined from scores on the Stanford.

There are other less commonly used instruments that do focus on science processes but each has significant shortcomings, particularly with regard to the range of science skills covered. Hungerford's test (Hungerford & Miles, 1969) measures only classification and observation skills. The instrument of Nelson, Abraham and Reynolds (1969) is limited to observation, inference and classification. The test of Lodge (1969) focuses only on measuring students' attitudes toward developing proficiency in science processes, not on measuring mastery of those processes. Although Tannenbaum's (1968) Test of Science Processes does measure a broader range of science skills it too has shortcomings: it is heavily content laden, it is limited to the secondary school panel, it suffers from some serious problems of administration (see Elgood, 1976), and it has validity problems (Lierres and Demers, 1980). Other unpublished instruments (reviewed by Mayer, 1974) suffer from similar deficiencies. Finally, there is the unpublished grade 8 problem-solving test developed by the OISE Intermediate Evaluation Project. There are only a few items specific to science and these items tend to focus on terminal objectives. Consequently, its use as a diagnostic tool for teachers is limited.

Local Need

The absence of suitable instruments to measure science inquiry skills, and the inability of teachers to construct their own tests to measure mastery of science skills, has been particularly problematic for the Peterborough County Board of Education. This Board has developed an extensive set of skill oriented curriculum guidelines in response to changes in Ministry of Education priorities in science. These documents are not being used to the extent or in the manner intended by the Board. Teachers are selecting from the guidelines the content portions and virtually ignoring the skill emphasis. The reasons for the inappropriate use of the document are twofold: the student behavioural dimensions of science inquiry skills are not delineated by the local guidelines nor do they provide assessment procedures that would enable teachers to determine if students are learning the designated skills.

The Board approached the principal investigators in the fall of 1977 with a request for assistance in meeting the assessment deficiencies of the Board's science guideline. With the support of $1700 in small scale OISE funding the principal investigators worked with a team of vice-principals in the Board to meet the needs of junior division teachers. By adapting procedures developed by Robinson and others (1976, 1977), this group identified the skills of scientific inquiry, described the levels of student growth for each skill, developed a small pool of test items and produced a manual for teachers (appended to this proposal).

The Board responded very positively to the products of this effort and requested that the work be extended in the following ways: by disseminating the teacher manual and pool of junior items, by increasing the pool of junior items, by developing a pool of intermediate items and by establishing grade level expectations for each set of items. Senior administrators identified these tasks as the top priority for Board-OISE cooperation and provided funding for release time for all Board personnel invited to participate on the project. The Board views these activities as an effective mechanism to increase the use of its science guideline and to meet Ministry expectations for local science programs.

Project Activities

Three integrated sets of activities were planned. The first set involved the dissemination of project outputs from the first year. This set of activities provided for ongoing inservice for teachers and school administrators, particularly for joint problem-solving sessions with teachers, directed by principals with the aid of members of the development committee. The data collection was designed to tie in with the inservice in that it required teachers to respond to the manual and test items. It also provided an opportunity for extensive user participation in the revision of the products and in the setting of grade level expectations for students.

The second set of activities were directed toward the production of test items for the intermediate division and the expansion of the existing junior item pool. The first step in this process was a revision of the skills organizer based on the responses from science educators external to the project. This revision took the form of revising particular growth schemes, especially for the skill of "judging the adequacy of data collected", and developing growth schemes for skills not yet addressed ("observing relationships in the summary data" and "using a data summarizing calculation"). The growth schemes are contained in chapter 3 of this report.

The activity of developing a test blueprint (Hopkins and Antes, 1978) which matches skills against content involved a search of the County guidelines for examples of fruitful inquiries which afforded an opportunity for students to demonstrate the requisite skills. This matching of skills against content was done to increase teacher and student recognition of the substance of the test items with familiar topics and to contribute to the integration of the test items with the Board guideline. The test items themselves do not require knowledge of content: all prerequisite content will be given in the item so that the item measures skill performance alone.

New items were constructed for each skill. The procedures used involved developing a stimulus from the selected context which requires the student to demonstrate competence on a given skill, constructing a series of response options that describe (using the appropriate growth scheme) how students at each level would behave, obtaining informal feedback from a few students using the test item with and without response options, and revising the item using student language to increase clarity. This set of events thus involves a replication of activities successfully completed by project participants in the first year.

The third set of activities involved field trials of new items. Workshops were held for science teachers in the junior and intermediate divisions. Participants at these sessions were introduced to the set of experimental skills identified in the project, the skills were defined and examples of items were presented. The resulting feedback from teachers and student reactions to the items were used to undertake a preliminary revision of the item pools. The item pools are contained in Chapters 4 and 5 of this report.

Impact of the Project

The primary impact of the project will be in the Peterborough County Board of Education in classrooms teaching science. (The population is estimated at 330 teachers and 7 500 students at the elementary level and 40 teachers and 800 students in grades 9 & 10.) The products of the project will give teachers a practical tool that will provide them with feedback on student skill development and on the effects of the science program. It will also assist the Board with the implementation of its science guideline and by extension with the implementation of Ministry of Education science objectives.

The secondary impact of the project will be in science classrooms in other boards, particularly in two boards that have expressed a desire for a role in the project. The test items and teacher manual can be used with little or no modification by other boards faced with the problems outlined in the rationale.

The tertiary impact of the project lies in its promotion of a generalizable approach to curriculum development. The 12-15 members of the working group are pursuing an approach to skill development (known as ICPOGMU) which is being applied to a broad range of curricular problems in the Board (and not incidentally in other boards across the province). Successful completion of the science project in year 16 will increase the curricular skills of participants, and dissemination of the products will heighten support within the Board for this approach to curriculum innovation, thereby increasing the contribution of the Institute to the resolution of practical problems of practitioners.

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3. Domain Definitions

Science is a method for making sense of the world in which we live. Science programs in most schools usually have three sets of objectives: we want to teach students some basic facts and concepts about the natural world; we want to develop appropriate student attitudes toward the natural world and its investigation; we want to teach students how to inquire into their environment. This manual is concerned with the last of these objectives. The focus here is on the skills of scientific inquiry, sometimes called the science processes or the skills of experimental thinking.

If we think of what a scientist does when he is doing an experiment, we would likely come up with a list like the following:

.the scientist begins by selecting a question that can be answered by doing an experiment;

.he develops a plan for collecting and organizing information about the question;

.he makes a record of his observations in carrying out the plan, making judgments about the adequacy of the information he is collecting;

.he summarizes his data and draws conclusions that answer his initial question;

.he extends his conclusions beyond the experiment to the real world;

.he reports the results of his experiment to an audience.

Each of the activities represents an important skill area to be developed in a science program. If we want to measure whether students have mastered each of these skills, we must do two things. First, we must define as clearly as we can what each skill means and provide a description of how someone who had mastered the skill would behave. Second, we must develop a valid and reliable way of testing the skill performance of students.

When it comes to defining the skills we usually think in terms of adult performance. We have an image in our minds of how we would act when demonstrating these skills. But adult performance is not a realistic expectation for a student in grade 4, grade 8 or even grade 10. What we have to do in defining these skills is describe science behaviors that would be appropriate to successful students at each grade level. Furthermore, we should try to describe behavior that would be appropriate to students of different ability levels: we want to be able to describe good experimental thinking when it appears in the work of the low and high ability students, as well as when it appears in the work of the average student. Furthermore, we want to be able to describe our goals for students in a way that will help us to improve their performance. Not only do we want to be able to say that a given student is or is not performing at the desired level; we also want to be able to say what the next step for this student is.

The definitions of science inquiry skills given in this manual are in the form of growth schemes. These growth schemes provide a hierarchy of behaviors for each skill; the heirarchy describes the performance of students at varying levels of sophistication with respect to each skill. Each level in the growth scheme corresponds to an increase in student competence that can be achieved in reasonable chunks of classroom time, such as a period, a week or a unit.

Expectations for students have not been developed. Each skill section has a part showing how a sample of students scored on the items relevant to the skill. Teachers are invited to set their own standards of performance, basing their expectations on the science backgrounds of their students, the ability of their students and the amount of instruction in the skill their students have received.

When it comes to measuring student performance on these skills there are several options. The growth schemes for each skill can be used as an observation scheme for rating pupil performance. This method requires a great deal of interpretation on the part of the observer. A second method which is much less problematic is to administer multiple-choice test items: this manual gives a bank of items for each skill. A third method is to give students open-ended items; that is to administer the items in this manual without the response options. The written answers of students can be analyzed using the growth schemes and by the choices given in the multiple-choice items as examples of responses at each level. Of the three methods the second is the most practical in the classroom situation because the items have already been developed and there are scores from a sample of students that can be used for comparitive purposes.

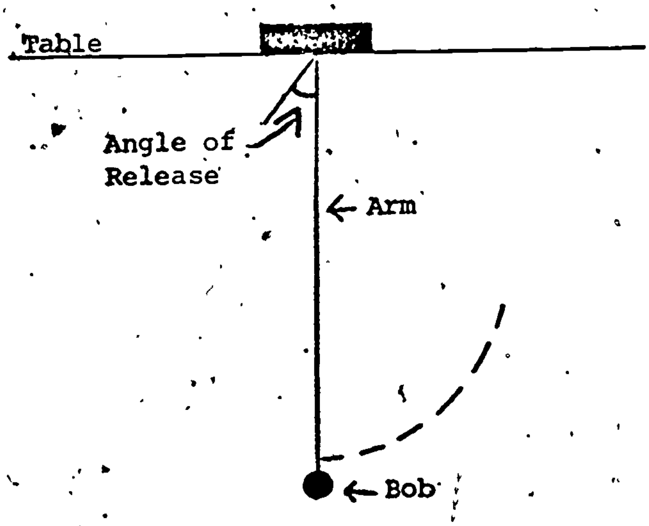
A few remarks about the items are in order. Each item tests one and only one skill. Each response option in the item corresponds to one and only one level of the growth scheme. Most of the items offer students a range of responses that vary in correctness. There are a few items that have one correct choice and a series of distractors (incorrect answers).

The items use content related to topics in the Board's science guideline (which in turn is based on the relevant Ministry guidelines). Therefore there may be an inclination to use a given item during or following instruction in the topic to which its content refers. This is not inappropriate and students may indeed be more comfortable when the information contained in the introduction to the item task is more or less familiar to them. However, it should be remembered that each item tests a skill, it does not and cannot test the acquisition of content knowledge (concepts, principles, facts).

Efforts have been made to ensure that all the content information necessary for completion of an item is provided in the stimulus portion (the question part). Any item may be used when a teacher wishes to know about the student's skill level; there is no need to wait until the content topic has been covered before administering it.

The item bank which follows contains an organizer that matches skills against core content of the county program, a section on each skill, and a final section describing how the items are produced. Each skill section contains a description (growth scheme) for the skill, a set of test items, an answer sheet for the items and a summary of student performance on the items.

In the description of the skill an example of a fairly typical experiment will be used. The diagram shows a drawing of a pendulum. A piece of string with a bob on the end of it is suspended from a table and held in place by a book. The swinging string functions as a pendulum.



The Pendulum

The key components (variables) are the length of the pendulum arm (i.e., the length of the string), the mass of the bob (the weight on the end of the arm), the angle of release (i.e., the angle between the table and the arm at the point of its release), the amount of force given the arm when it is released (i.e., the arm can be dropped or pushed), and the period (i.e., the time required to complete one complete swing in the bob). Typical experiments involve the student trying to determine which of these variables affect the period. These experiments conclude that the period of the pendulum is positively related to the length of the arm and is not affected by other variables.

A. Developing A Focus For A Scientific Inquiry

Developing a focus for a scientific inquiry involves the development of a clearly stated question or hypothesis from a problem situation. Analysis of questions that students pose reveals the following dimensions of growth.

Dimensions	Categories
a) number of variables	0, 1, 2, or more than 2
b) precision of causal language	noncausal, precausal, ambiguous causal, causal or scientific

These dimensions can be combined into the following sequence of growth. Examples of questions or hypotheses given at each level are from the pendulum experiment.

Level 1: No variables/noncausal request for identification of object

This type of question involves only a request for definition of the object or requires merely a labelling of parts of the equipment. There is no reference to specific variables and no reference to causes and effects. Examples of questions at this level for the pendulum experiment include: "What is it?" or pointing to a part of the pendulum, "What's that?"

Level 2: No variables/ noncausal request for definition of function

This type of question is similar to level 1 questions in that it has no clearly stated variables and does not employ causal language. But it does involve a searching for some kind of effect or interpretation of movement. For example, "What's it (the arm of the pendulum) doing?" "How does it (the pendulum) work?"

Level 3: 1 variable/precausal language

This type of question introduces a variable in a primitive way and begins to grope toward causal language. For example, "Will it (the bob) go faster?" "Will it (the bob) go slower?" In these examples the primitive variable is the speed of the bob. The student has the idea that this primitive variable can change in value, but there is no explicit reference to cause and effect.

Level 4: 1 variable/ambiguous causal language

In this type of question an effect is specified as a variable. The cause of this effect is unstated and only hinted at. For example, "How can you make it (the bob) go faster?", where the speed of the bob is the effect and the cause is hinted at or indirectly addressed by the how.

Level 5: 2 variables/explicit causal language

Questions at this level clearly specify 2 variables. One variable is a potential cause, the other variable is the potential effect. However, the student may focus on a specific change in the causal variable, for example, "If I make the string (the arm) longer will it make a difference to the amount of time required to make one complete swing?" "If I increase the angle of release will the time required to make a complete swing be affected?"

Level 6: 2 variables/precise scientific statement

Questions at this level differ from Level 5 questions in that the full range of variation in both the cause and effect variables is being considered and more precise "scientific" language is employed. Hence the student at this level might ask, "Does the length of the arm affect the period?" or "Does the amount of force applied to the bob affect the period."

Level 6a:

A slightly more advanced student may ask a series of 2 or more Level 6 questions about the effect of several potential causes of the same effect, thus, "Is the period affected by the length of the arm, or the amount of force applied to the bob, or the mass of the bob, or the angle of release?"

Level 7: more than 2 variables

Questions at this level specify more than 2 variables, but rather than asking about each potential cause in an essentially separate question the student now links them to show that possible interacting effects are being considered. A three variable example is "Does the effect of force on the period depend on the length of the arm?" or, restated, "Is the effect of force on the period different for different arm lengths?"

Testing: Levels 1 through 6 (but not 6a) are tested in the Junior Division. Levels 4 through 7 are tested in the Intermediate Division.

B. Developing A Plan For Collecting And Organizing Information

Developing a plan for collecting and organizing information refers to the mental image of the problem and its solution. Such a mental image includes a set of variables and a hypothesized relationship. This mental image is very difficult to communicate to another person; hence it is very difficult to measure. The mental image or framework or plan can be represented as a data table, a graph, a set of steps in an experimental procedure or as a description of how to find out if an expected relationship does exist. In assessing the adequacy of student frameworks the important thing is not the form in which it is expressed but these dimensions:

Dimensions	Categories
a) number of variables	0, 1, 2, more than 2
b) use of control variables	no controls, conditions kept the same, systematically varying a control variable

These two dimensions can be combined into the following levels of growth:

Level 1: No variables

At this level the student is essentially playing with the equipment. He is not investigating a specific question but only manipulating the equipment. In the pendulum experiment this might mean swinging the arm of the pendulum back and forth simply because this is an obvious thing to do with it. The student might unconsciously vary the angle of release or the amount of push given to the arm as it is released but he is really not aware that any of his actions could be related to the pendulum's period (the length of time the arm takes to make a complete swing).

Level 2: Manipulating a variable to see what happens

This too is a pre-experimental stage. The student is not investigating a clearly defined question or hypothesis. What he does is change something to see if anything else is changed. The changes he tries have a purpose but they are not systematic. Each involves a single variable; there is no plan to measure a second, dependent, variable (the effect) or any particular idea of how that effect might manifest itself. In the case of our pendulum example the student may decide to try lengthening the string (the arm of the pendulum) to see what will happen: he has no expectations of the result.

Level 3: Manipulating 2 variables with no attempt to keep conditions the same

At this level the student is engaged in a genuine experiment. In the case of the pendulum he might lengthen the string (the arm of the pendulum) to see if this will change the amount of time it takes for the bob to make one complete swing (i.e., he is trying to determine if the length of the arm affects the period). At this level there is no attempt to control other variables which might affect the result. For example, the angle at which the student releases the arm of the pendulum or the amount of push the student exerts on the arm when releasing the arm may affect the period of the pendulum. At this level the student is unaware of the need to control for the possible distortion of his results by these uncontrolled factors.

Level 4: Manipulating 2 variables while keeping other variables constant

At this level the student is aware that the relationship between two variables might be influenced by other factors. He attempts to deal with this problem by keeping these other factors constant. For example, a student at this level trying to find out if the period of the pendulum changes when the length of the arm is increased from 10 cm to 20 cm might make sure that he releases the arm from the same angle and with the same amount of push when the arm is 20 cm long as when the arm is 10 cm long.

*Level 4a: Manipulating more than 2 variables in pairs

This level is only a slight advance from level 4: it will not be tested in the items but it is included because it is a useful step in helping students master level 5. Students at this level handle questions involving more than 2 variables by doing a series of 2 variable experiments. In the pendulum example a student who wanted to find out what would make the arm of the pendulum go faster might identify the length of the arm and the weight of the bob as factors which influence the period. At this level the student would test for the effect of the length of the arm on the period and then separately test for the effect of the weight of the bob on the period. He would keep other factors (such as the angle of release and the amount of push given on release) the same in all cases.

Level 5: Manipulating 2 variables while systematically varying a third

At this level students are testing for a relationship between two variables while controlling for a third. The difference between this level and level 4 is that at level 4 students are controlling variables by keeping the same value of the control variable in all situations. At level 5 students are controlling variables by finding out if the relationship they are examining is maintained in several values of a control variable. For example, a level 5 student who wanted to find out if the length of the arm affects the period might determine the period when the arm is 10 cm, 20 cm and 30 cm using a bob that has a mass of 1 g. He might then repeat the experiment to determine if the relationship between length of the arm and the period remained the same when bobs having a mass of 3 g, 5 g and so forth were used.

Testing: Levels 1, 2, 3 and 4 are tested in the Junior Division.
Levels 2, 3, 4 and 5 are tested in the Intermediate Division.

A third dimension, which has not been included in the growth scheme, concerns the student's degree of independence in selecting a framework or plan. At the lowest level, the student would be able to follow a plan (experimental procedure) given by a teacher or textbook. More sophisticated students would be able to participate in the development of a framework collectively with the guidance of the teacher. Much more sophisticated students would be able to develop their own framework for an experiment after being reminded by a teacher that a plan developed for a previous experiment is relevant. The most sophisticated students would be able to develop their own frameworks without prompting from the teacher. This dimension will not be tested in the items. It is offered as a way of categorizing student behaviour for purposes of classroom observation.

C. Judging the Adequacy of Data

After the data from the experiment has been collected there is a crucial set of issues to be addressed. Is the information of sufficient volume, accuracy and relevance to deal with the problem? The skill of judging the adequacy of the data involves answering these questions. There are several distinct dimensions to the skill:

a) The data collected must be relevant to the problem. That is the student must have collected information on the relationship of the specific variables in his experimental plan. This dimension is addressed in the skill of recording data.

b) Data about the relationship between one set of variables should not be confounded by distortions that arise by failing to control for the effects of other variables that might affect the relationship. This dimension is addressed in the skill of developing a plan: in that growth scheme distinctions are made between plans that fail to control for intervening variables (levels 1, 2 and 3), plans that try to keep other variables constant (level 4) and plans that systematically control for other variables (level 5).

c) The third dimension concerns measurement error. All information collected in an experiment has an error component. What distinguishes students with respect to the skill of judging the adequacy of data is the amount of error that exists in their data (i.e., the adequacy of the procedures used to collect the information) and strategies used to deal with error.

A sample of experimental procedures that students should be able to perform has been identified. These include such things as measurement procedures, general control procedures and procedures to follow when unexpected or conflicting results are encountered. A series of test items focusing on the correct performance of each procedure has been developed. No stages of growth have been described.

A variety of strategies could be used by students to deal with residual measurement error. In order of sophistication, these strategies are: ignore the error (accept the data uncritically), repeat the experiment several times (i.e. have multiple trials of the experimental treatment), and employ statistical strategies to measure the error (e.g. compare the amount of variance between trials to the amount of variance between experimental conditions). No test items have been developed to measure these differences in strategy.

D. Recording Information

The skill of recording information refers to the written records a student makes of his observations. The task for the student is to organize the information collected so that it is possible to see the relationships among the variables and answer the experimental question. That is, the student must fill in the information required by his plan. Information can be recorded in a graph or in a data table. The following are the dimensions of growth:

Dimensions	Categories
a) number of variables in problem	2 variables (level 3 plan) or more than 2 variables (level 5 plan)
b) use of relevant data	correct (all relevant data used) or incorrect (too little data, includes irrelevant data; focuses on wrong relationship or fails to cross-classify the variables

These dimensions can be used to describe three levels of growth on the skill:

Level 1: Student is unable to record data appropriately

The student at this level fails to record data appropriately. As an example we might consider a simple experiment in which a group of students measured the effect of changing the length of the pendulum arm (from 10 cm to 20 cm, 30 cm and 40 cm) on the period of the pendulum (based on 10 complete swings of the arm). A student who is unable to record the data appropriately would make one or more of the following errors:

a) student includes data that is not relevant to the problem; in the example opposite the student has included relevant information (the length of the arm and the period) but has included irrelevant information as well (the names of the students who released the pendulum arm)

Length of Arm	Period (10 swings)	Person Releasing Arm
10 cm	10.1 s	Mary
20 cm	19.7 s	Bill
30 cm	31.4 s	Tom
40 cm	39.6 s	Tom

b) student omits relevant data; in the example opposite the student did not record the data collected when the arm was 30 cm and 40 cm long

Length of Arm	Period (10 swings)
10 cm	10.1 s
20 cm	19.7 s

c). student focuses on the wrong relationship; in the example opposite the student recorded data relevant to the length of the arm and the distance travelled by the arm rather than data on the variables given in the question

Length of Arm	Distance Travelled by the Arm
10 cm	7 cm
20 cm	14 cm
30 cm	21 cm
40 cm	28 cm

d) student fails to cross-classify the data by the variables; in the example opposite the student has produced 2 separate tables - one for length of the arm and one for period of the pendulum; because the tables are separate it is impossible to determine if one variable causes changes in the other

Length of Arm
10 cm
20 cm
30 cm
40 cm

Period of Pendulum (10 swings)
10.1 s
19.7 s
31.4 s
39.6 s

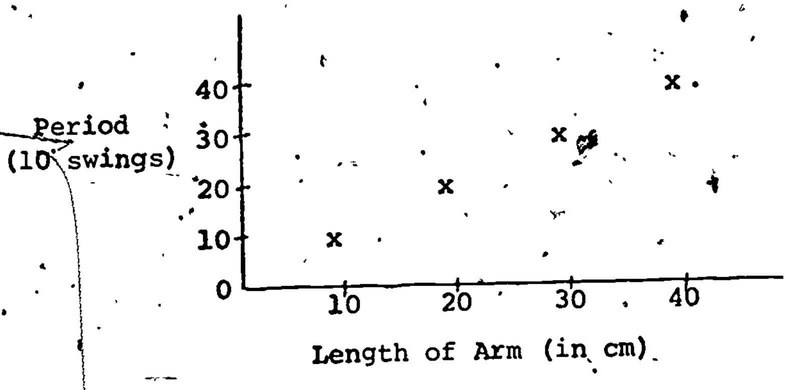
*e) student fails to sequence the data on one of the variables; (this is rare in an experimental problem because the order is usually given to students); in the example opposite it is difficult to see the relationship because neither variable is sequenced.

Length of Arm	Period (10 swings)
20 cm	19.7 s
40 cm	39.6 s
30 cm	31.4 s
10 cm	10.1 s

Level 2: Student records data appropriately in a 2 variable experiment

The student at this level avoids all of the errors listed above in level one. Both of these examples for the pendulum experiment are correct.

Length of Arm	Period (10 swings)
10 cm	10.1 s
20 cm	19.7 s
30 cm	31.4 s
40 cm	39.6 s

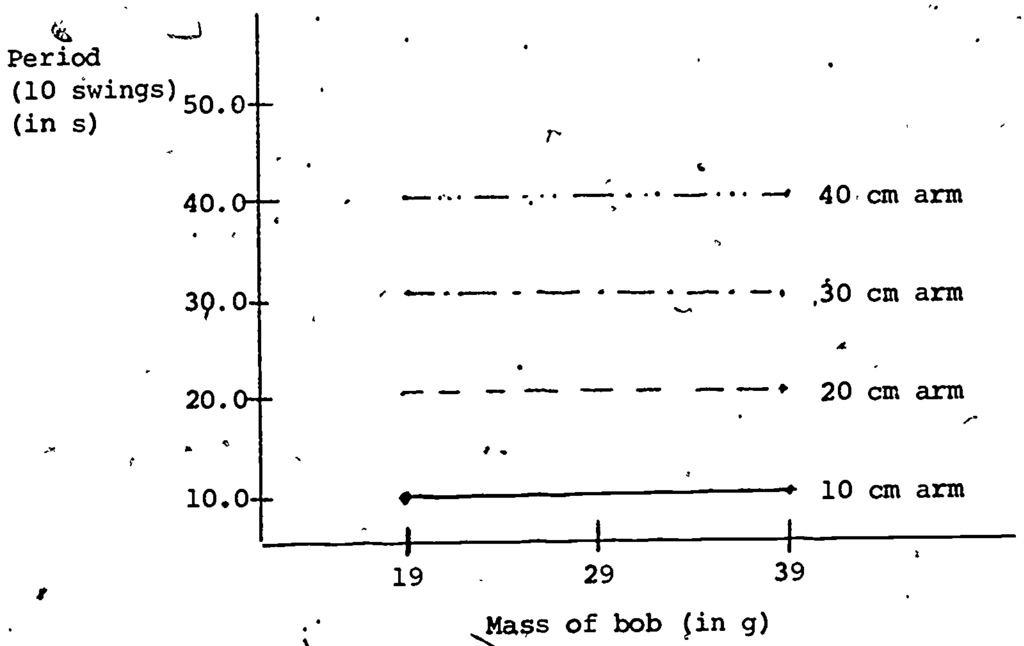


Level 3: Student records data appropriately in an experiment with more than 2 variables

The student at this level avoids all the errors listed above in level 1. What distinguishes this student from level 2 is that he is able to record data in a more complex problem. The following table and graph are alternative ways of recording information in an experiment to find out if the affect of the length of the pendulum arm on the period is influenced by the mass of the bob.

Period (10 swings) in seconds

Length of Arm	1 g bob	2 g bob	3 g bob
10 cm	11.4	10.1	9.6
20 cm	20.3	19.7	19.9
30 cm	29.8	31.4	30.4
40 cm	40.2	39.6	41.6



Testing: Levels 1 and 2 are tested in the Junior Division
Levels 1 and 3 are tested in the Intermediate Division

E. Growth Scheme for Observing Relationships in Data

Observing relationships in data in an experimental problem involves the examination of previously developed data tables or graphs to find trends in the data. The task is to determine whether there are relationships between the variables in the study. This skill is very closely linked to the skill of concluding: it describes the capacity of the student to process information. It helps diagnose the difficulties of students who are unable to draw appropriate conclusions. The dimensions of the skill of observing relationships are:

Dimension	Categories of Growth
a) number of cases used	a limited selection or all the cases
b) amount of information about each case used	1, 2 or 3 variables
c) sophistication of strategy used	eyeball scrutiny or computational strategy

These dimensions can be combined into a growth scheme which will be described using an example of data collected in an experiment involving marbles rolling down a ramp. The first 5 levels refer to a simple experiment in which only 2 variables are involved. The sixth level requires additional data for a more complex problem concerning 3 variables.

Mass of Marble		Distance Travelled by Marble
1 g	1st trial	12 cm
	2nd trial	14 cm
	3rd trial	11 cm
2 g	1st trial	17 cm
	2nd trial	16 cm
	3rd trial	19 cm
3 g	1st trial	24 cm
	2nd trial	22 cm
	3rd trial	23 cm

Level 1: Limited selection of cases/1 piece of information

The student at this level tries to observe relationships by considering the information about 2 variables provided for a single case. For example, the student might look to see what happened with one of the marbles, for example, the 1 g. Even though he has information about 3 trials with this marble he will not be able to observe any relationship because he looks at only one mass.

Level 2: Limited selection of 2 extreme cases/2 pieces of information about each

The student at this level selects the two cases which have the highest and lowest values on one of the variables in the study. For example, a student might pick out the longest distance (24 cm) and the shortest distance (11 cm). Since the longest distance is produced by the biggest marble (3 g) and the shortest distance by the smallest marble (1 g) he might decide there is a relationship between mass of the marble and distance travelled.

Level 3: Limited selection of a few cases/2 pieces of information about each

The student at this level tries to observe relationships by considering the appropriate information about a few cases arbitrarily chosen. For example, a student might focus on the second trial in each set and try to determine if the distance travelled increases as the mass of the marble increases. This student ignores the other cases in the data table.

Level 4: All cases/2 pieces of information about each/eyeball scrutiny

The student at this level uses all the cases. The cases are grouped on one variable: the student looks down the column for the other variable to see if the same order or pattern exists. If there is a consistent pattern he is able to determine if there is a relationship between the two variables. For example, the student at this level might observe that the distances travelled tend to increase between each group. Since the mass of the marble increases between each group, he might observe that there is a relationship between the marble's mass and distance travelled.

Level 5: All cases/2 pieces of information about each/computational strategy

The trouble with the level 4 method for observing relationships is that deviant cases in the pattern, or weak relationships, make it difficult to observe the appropriate relationships. The student at level 5 calculates averages for each set of cases and then observes if there is a relationship. For example, a student might calculate that the average distance the marble rolls increases (12.3 cm, 17.3 cm and 23 cm) as the mass of the marble increases (1 g, 2 g and 3 g). More sophisticated computational strategies are appropriate for the Senior Divsion. A student at this level might also select median cases.

Level 6: All cases/3 pieces of information about each/eyeball scrutiny

This level requires additional data for the third variable. In the example provided, the data for each set of three trials has been averaged.

Height of Ramp	Average Distance Rolled 1 g marble	2 g marble	3 g marble
10 cm	20 cm	40 cm	80 cm
15 cm	30 cm	60 cm	120 cm
20 cm	40 cm	80 cm	160 cm

A student at this level might be trying to find out if one variable affects a second variable while a third variable is systematically altered. For example, does the mass of the marble affect the distance rolled when the height of the ramp is varied. A student at this level would examine the data for the first row of the table. He would find that when the ramp is 10 cm high, the distance rolled increases with the mass of the marble. Then he would examine the second row of the table and observe that the distance rolled increases with the mass of the marble when the ramp is 15 cm. Then he would examine the third row of the table and observe the same relationship. He would summarize his observations by saying that the mass of the marble affects the distance rolled when the height of the ramp is changed.

Testing: Levels 1, 2, 3, 4 are tested in the Junior Division.
Levels 2, 3, 4, 5 are tested in the Intermediate Division.
Level 6 is tested in the Intermediate Division.

F. Drawing Conclusions

The skill of drawing conclusions is extremely close to observing relationships. Drawing conclusions is the skill of interpreting relationships and relating that interpretation to the focus or hypothesis of the experiment. Conclusions reached apply to the experiment only and are therefore stated in the past tense. The major dimensions of the skill are:

Dimensions	Categories
(a) number of variables in the relationship	2 or more than 2
(b) direction of relationship	positive (direct) or negative (indirect)
(c) nature of relationship	linear or curvilinear
(d) size of relationship	ratio or nonratio

These dimensions can be combined into the following sequence of growth:

Level 0: Identifies incorrect conclusion

The student at this level simply states an incorrect conclusion. The basis for his error is likely to be uncovered in the previous skill concerned with the procedure used to observe relationships in data.

Level 1: Discovers two variables were related

The student at this level discovers that two variables were related but does not specify the nature of the relationship; for example, "changing the length of the arm affected the period of the pendulum."

Level 2: Identifies positive or negative relationship between two variables

At this level the student identifies a relationship between two variables and specifies whether the relationship was positive or negative; for example, "increasing the length of the arm increased the period of the pendulum" or "the period was positively related to the length of the arm."

Level 3: Discovers 3 variables are related (pairs of main effects)

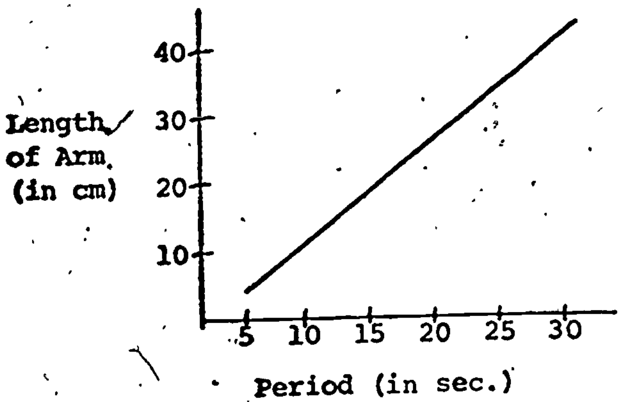
The student at this level has completed an experiment in which 3 variables are involved but his conclusions treat the variables in separate pairs. For example, a student who has done an experiment involving plant growth might conclude that the height of plants was positively related to the amount of sunlight they received and the height of plants was positively related to the amount of water they received.

Level 4: Discovers 3 variables were related (main effects and interactions)

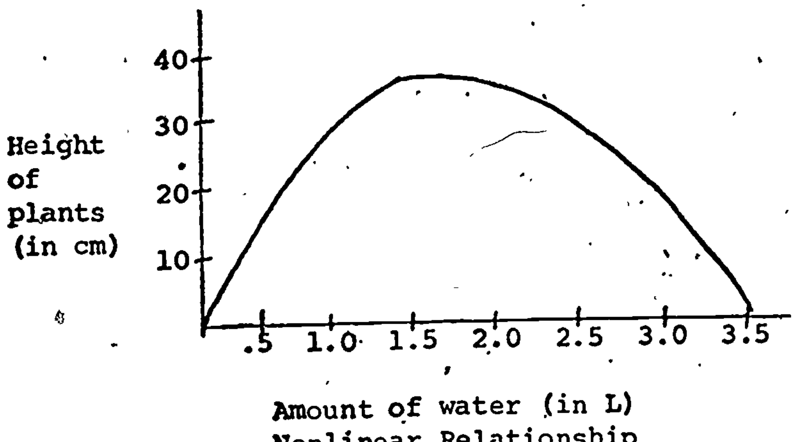
At this level the student has completed an experiment in which 3 or more variables are involved and his conclusions concern the interaction of all 3 variables. For example, "the period of the pendulum was positively related to the length of the arm regardless of the mass of the bob" or "the effect of increasing the amount of water and the amount of sunlight on the growth of plants was greater than increasing either water or sunlight alone."

Level 5: Discovers non-linear relationships between 2 or more variables

At all previous levels the student was making conclusions about linear relationships; at this level he discovers non-linear relationships.



Linear Relationship



Nonlinear Relationship

Note: Advanced levels can be identified at each of levels 2, 3, 4 and 5; they describe the student who is able to add an additional piece of information by quantifying the relationships that were found. For example, an advanced level 2 student might conclude, "When the length of the arm was doubled the period was also doubled."

Testing: Levels 0, 1, 2 and 3 are tested in the Junior Division

Levels 0, 2, 3 and 4 are tested in the Intermediate Division

Level 5 is not tested.

The advanced levels of levels 2 to 5 are not tested.

G. Generalizing/Extrapolating/Predicting About Probable Results in New Situations

This skill involves using the conclusions of an experiment to make statements about what is expected in events of a similar nature, now or in the future. Thus a student may use the results of his inquiry to draw conclusions about not only repetitions with the same conditions as his experiment, but about conditions in the real world (grandfather clock pendulums, as well as weighted string pendulums) or to predict, based on the relationships he has discovered, the probable outcomes with other values of the factor he has tested (for example, pendulum lengths that fall between the lengths he used, or that are longer or shorter than any he used).

The point of experimental trials of possible factors which make a difference to things of interest is, of course, to be able to make such general or inclusive statements or to predict what is likely to happen in future real-world happenings. Students are encouraged to actively seek contexts in which their results apply and to use correctly the facts of the relationship they have discovered in these new contexts. It is also important, however, that they learn to assess whether the same kind of results are probable, and if so how probable, as the conditions of the new context and the values of the factor which has been found to make a difference grow less similar to those of the experiment.

Two dimensions are involved:

a) Correct Use of Discovered Relationships

The first 3 categories of this dimension are concerned with two-variable (the factor making a difference and the factor affected) straight-line (as the factor making a difference increases or decreases the factor affected shows regular increases or decreases) relationships (as in the diagram in Fig. 1)

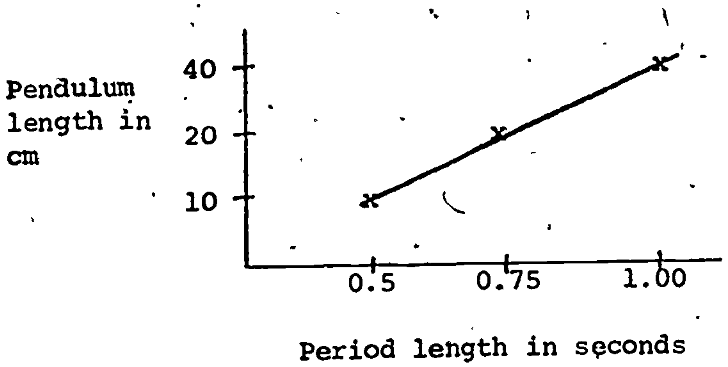


Fig. 1

The child who has moved beyond an inability to generalize at all to the earliest level recognizes only that the effect should be operating in the new context (the first factor is making a difference to the second one); later he can specify the direction of the difference (that increases in one will increase or decrease the other); at the third level he can use the facts of the experimental outcomes to calculate how much these increases or decreases should be.

The final two categories have to do with more complex relationships. The first of these is concerned with relationships that are "curved" rather than straight lines (that is, if values of the two factors were plotted on a graph there would be changes in the direction of the line produced. (As for example, in Fig 2). With these effects, then, the direction of the effect can vary with the amount of the factor that makes a difference. At the final

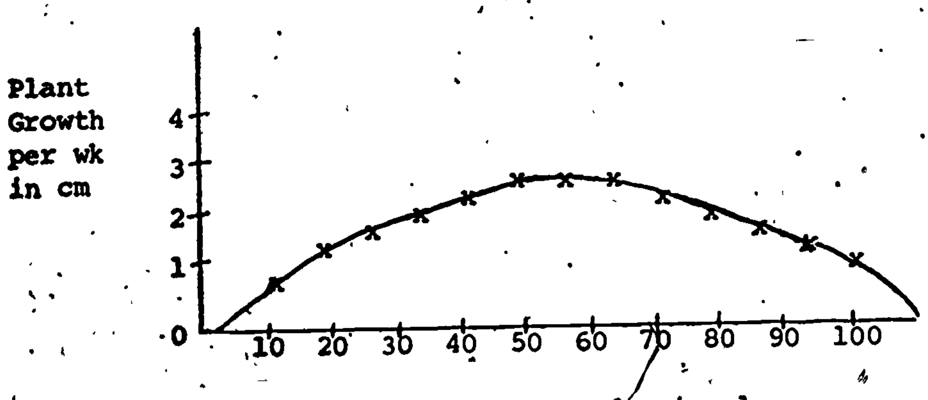


Fig. 2

level, students are learning to deal with effects produced by a complex of two or more interacting factors when generalizing or predicting what happens in situations beyond that of the experiment itself.

b) Assessment of Probability

This dimension is reflected in the developing ability of a student to be critical of potentially appropriate new contexts in which to apply his findings, and to modify his generalizations or predictions accordingly. Thus the younger student is apt to feel he has discovered a truth that applies indiscriminately to all places and at all times. With increasing maturity and experience he enters a transitional phase where he may doubt the application of his results when the contexts, or the values of the independent variable (the factor that makes a difference) are very different from those of his experiment. Finally, he reaches a mature level where he is critical of each new context and actively assesses each in terms of the probability that a discovered relationship will hold. The difference in this student is that now he searches for factors in the new context that could alter the results. When doing this he will consider both the conditions (same as the experiment, different but so similar they may be placed in the same class, and different because of the presence of other factors which place class membership in question) and the values of the independent variable, (which may be the same as those tested, different but within the range tested, or either a small or large amount greater or lesser than any of the values about which information has been discovered).

These two considerations may be placed together to form the following table:

Values Of The Independent Variable

Conditions	Same as tested values	Within the tested range	Larger or Smaller Than Tested Values: By a small amount	Larger or Smaller Than Tested Values: By a large amount
Same as experiment	1	2	2	2 or 3
Real-world but same class	2	2	2	3 or 4
Different class (other factors present)	3 or 4	3 or 4	3 or 4	3 or 4

Obviously the probability that the relationship holds will decline as one proceeds from the upper left-hand cell, which describes an exact repetition of the experiment, to the lower right-hand cell which describes a situation with both similarities and differences in the conditions and with values of the independent variable which differ greatly from those for which information exists. The numbers in the cells are attempts to categorize (fairly roughly) the probability of predictions based on the discovered relationship, given the situations described by each cell, as follows;

1 = almost certainly true
2 = probably true
3 = may or may not be true
4 = unlikely to be true

Thus in the upper left-hand cell the only differences one would expect would be due to small errors in measurement. Continuing through the cells of the table, repetition of the experiment (e.g. uses weighted strings for pendulums) or essentially of the same class (e.g. a grandfather clock), it is probable the relationship would be unaltered. However, if the values of the independent variable differ, especially by a large amount (e.g. a pendulum several metres in length when the longest one tested is 40 cm) the probability would be assessed as somewhat reduced by someone who has no other information about pendulums. When there are new factors in the conditions (e.g. the grandfather clock sits on a tilted table or floor) predictions would be "may or may not be true" or are "unlikely to be true" depending on what is known about the probable effect these other factors would have.

The two dimensions, "correct use of the relationship", and "assessment of probability" may then be summarized as follows:

Dimensions	Categories
a) Correct use of relationship	Effect with no direction or amount; positive or negative effect with no amount; positive or negative effect with amount; effects that vary in direction with amount; complex effects
b) Assessment of probability	No differences among situations; extreme differences assessed; all new situations assessed

These dimensions can be combined into the following levels:

Level 0: No new situations identified

Level 1: Equally probable effect expected in all situations

The student at this level is aware, for example, that the length of the arm affects the period but is unable to predict the specific effect, in a new context such as a real grandfather clock, of lengthening or shortening the arm. Further, he would ascribe the effect to any swinging arm, whatever the circumstances.

Level 2: Correct direction of effect expected with equal probability in all but very obviously different situations

At this level the student is able to correctly predict the direction of the effect in other situations. When applying the results of the pendulum experiment to grandfather clocks, for example, the student would realize that lengthening the arm will lengthen (not shorten) the period. He can also correctly apply the direction of a negative relationship). On his own, however, the student does not differentiate among most situations, expecting the relationship to exist with equal probability in all but very different circumstances (such as, perhaps, a grandfather clock on a tilted or uneven floor).

Level 3: Correct direction and amount of effect expected with equal probability in all but very different situations

At this level the student can use the data of the experiment to correctly determine the size of the expected effect, as well as its direction. He still, however, fully expects the relationship to hold for all but very different circumstances.

Level 4: Correct direction and amount of varying effects expected with differing probabilities depending on circumstances

The student at this level can correctly apply more complex relationships where the amount and direction of the effect can vary depending on the strength of the factor which produces it (as, for example, in the relationships of water or fertilizer to plant growth).

The big difference in students at this level, however, is their awareness of the variations in probability that the same result will be found in new contexts. Such students take into account, as was described above, both the conditions (is the new context a member of the class of conditions to which the experimental conditions belong or are there new variables present which affect its class membership) and the values of the variable about which the prediction is made.

Level 5: Correct direction and amount of complex, 2 or more variable effects expected with differing probabilities depending on circumstances.

This level describes the individual who can deal with effects that are determined by interacting factors when assessing how his results apply beyond the experiment in which they were discovered. This student also assesses the effect of differing circumstances and modifies accordingly his estimate of the probability that the relationship will hold.

Testing

Although the 2 dimensions have been combined when describing levels they are tested separately.

For dimension (a) - Separate items with sub-items each containing a correct response and a set of distractors are provided for each of levels 2 (junior), and 3 (intermediate) (levels 4 and 5 are not tested). Students who fail level 2 are assumed to be at level 1 or lower. Students who fail level 3 should be tested with the next lower level. Students who pass level 3 are assumed to be at least at this level.

For dimension (b) - Students who pass the items provided for this dimension are assumed to be at least at level 4 of the growth scheme with respect to this dimension. Students who fail are assumed to be below level 4 on this dimension. This dimension is tested in the intermediate division.

4. Junior Division Item Pool

The items have been grouped in terms of skill, using the same sequence that was followed for the presentation of the domain definitions (growth schemes).

In each case a marking sheet precedes the items.

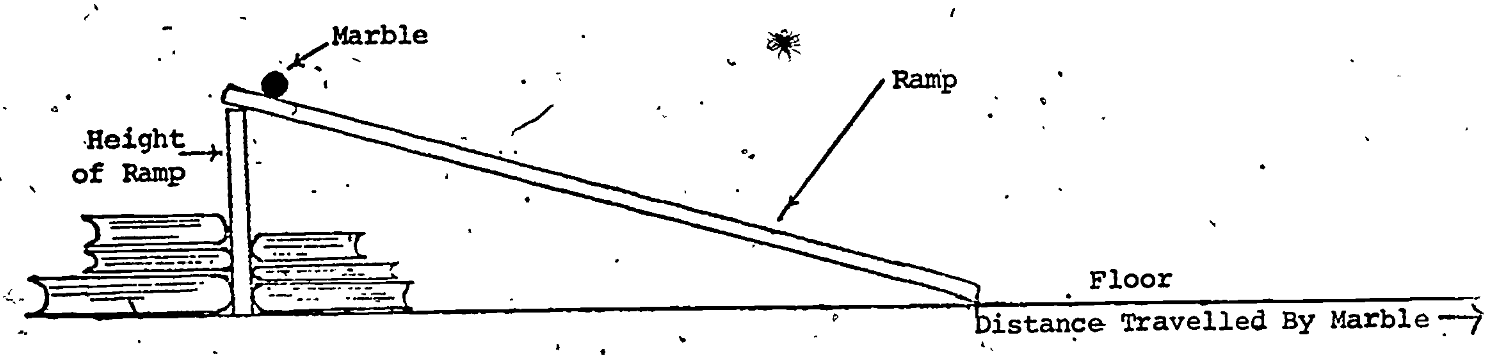
A. QUESTIONING - Junior

Answer Sheet

Items	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1. Ramp	c	b	e	a	f	d
2. Sound	b	d	f	a	e	c
3. Bicycle	b	d	c	f	e	a
4. Shadows (a)	a	d	b	f	c	e
5. Shadows (b)	b	a	c	f	e	d
6. Magnets (a)	d	e	a	f	c	b
7. Magnets (b)	e	d	b	a	f	c
8. Solutions	f	b	c	e	a	d
9. Plant Requirements - Fertilizer	a	c	b	f	d	e
10. Pendulum	b	a	c	e	d	f
11. Water and Heat	c	f	a	e	d	b

1. Ramp

Mary built a ramp using a board and some books. She wanted to use it to roll marbles down the ramp onto the floor. Mary had several marbles of different size.



Directions: Suppose Mary wanted to experiment with her equipment. Which would be the best question she could ask?

Circle the letter of your choice.

(a) How can I make the marble roll further?

(b) What will the marble do?

(c) What is the name of this equipment?

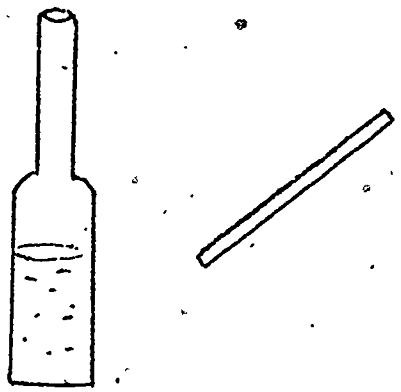
(d) Does the size of the marble affect the distance it will travel across the floor?

(e) Can I make the marble roll further?

(f) Would the marble roll further if it was bigger?

2. Sound

There is a glass jar with some water in it. If you strike the jar with a glass rod it makes a sound.



Directions: Suppose you wanted to experiment with this equipment. Which would be the best question to ask?

Circle the letter of your choice.

(a) What should I do to get different sounds?

(b) Which musical note is the sound?

(c) Does the height of water in the jar affect the pitch of the sound it makes?

(d) What can I do with the bottle and rod?

(e) If I put more water in the jar can I get a different sound?

(f) Can I get different sounds with the bottle and rod?

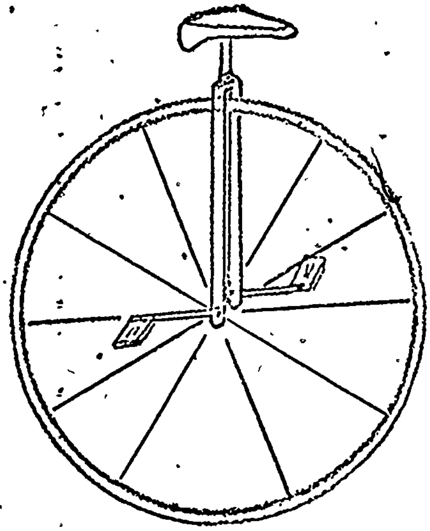
Questioning

Junior Item

3. Bicycle

John was visiting his uncle. There was a unicycle wheel like the one in the picture stored in the garage. He got it out to look at it.

Unicycle Wheel



Directions: Suppose John wanted to experiment with the wheel. Which would be the best question he could ask?

Circle the letter of your choice.

(a) Does the number of spokes in the wheel affect the weight it will hold?

(b) What kind of thing can that be?

(c) Can just little people ride on the wheel?

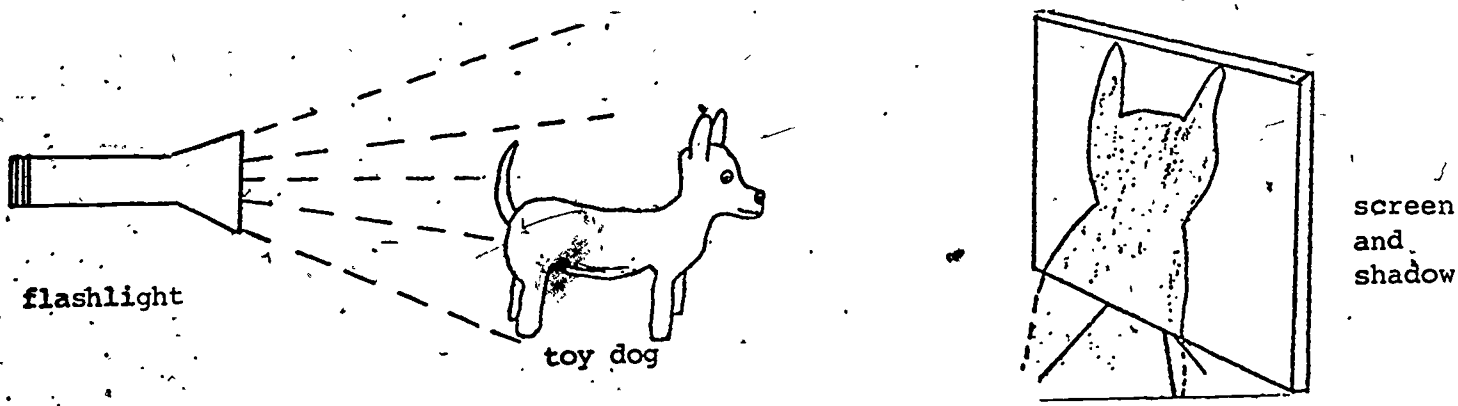
(d) What can you do with this strange wheel?

(e) If you put in more spokes will it hold more weight?

(f) How can you make the wheel hold heavy people?

4. Shadows (a)

Carole takes her pup, Kelly, for a walk at night. She carries a flashlight. Sometimes they walk towards a yard with a high wall around it. When the pup sees his large shadow ahead of him on the wall he gets frightened and turns back. So far Carole has not made him go any closer to the wall.



Directions: Suppose Carole had a flashlight, a screen and a toy dog. If she wanted to do an experiment which would be the best question for her to ask?

Circle the letter of your choice.

(a) What is a shadow?

(b) Can I make a shadow smaller?

(c) If I move the dog closer to the screen will the shadow get smaller?

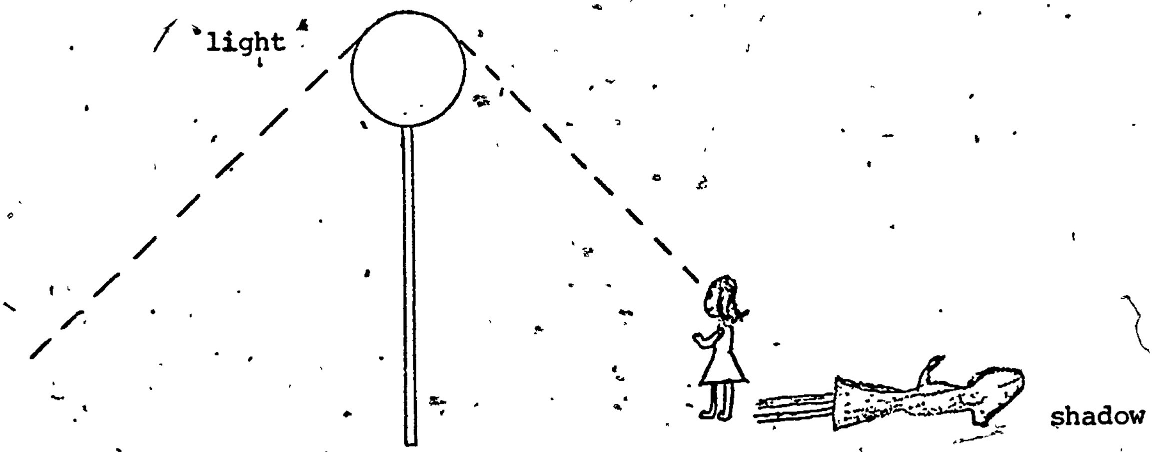
(d) What does a shadow do?

(e) Does the distance of the dog from the screen affect the size of the shadow?

(f) How can I make the shadow smaller?

5. Shadows (b)

Heather watches her shadow when she walks home at night from her friend's house. It changes as she gets closer to the light on the corner. When she walks away from the light it changes again. Heather is puzzled.



Directions: Suppose Heather put a light on a stick in a dark room. Suppose she used a paper doll to be herself. If she did an experiment, which is the best question for her to ask?

Circle the letter of your choice.

(a) What does a shadow do?

(b) I wonder what a shadow is?

(c) Can the length of the shadow change?

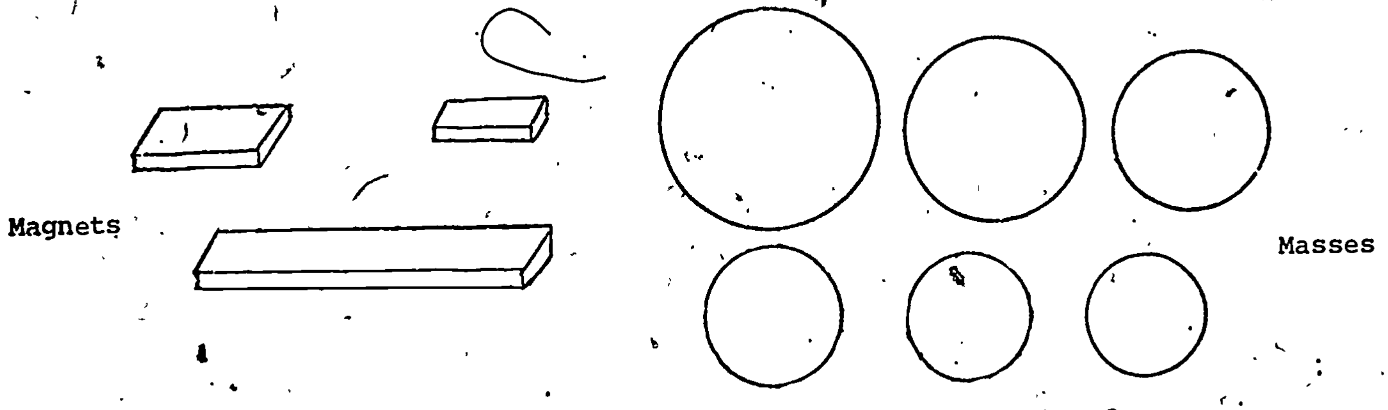
(d) Does the distance of the doll from the light affect the length of the shadow?

(e) If I move the doll closer to the light will the shadow get shorter?

(f) How can I make the length of the shadow change?

6. Magnets (a)

Gerry has some bar magnets of different sizes. He also has some pieces of steel of different masses. He is lifting the masses with the magnets. His friend Steve wonders what he is trying to do.



Directions: Suppose Gerry said he would try and answer a question for Steve by doing an experiment. Which question do you think would be best for Steve to ask?

Circle the letter of your choice.

(a) Will the little magnet attract the masses?

(b) Is the size of the magnet related to the mass of the object it will attract?

(c) Do you need a larger magnet to attract the larger masses?

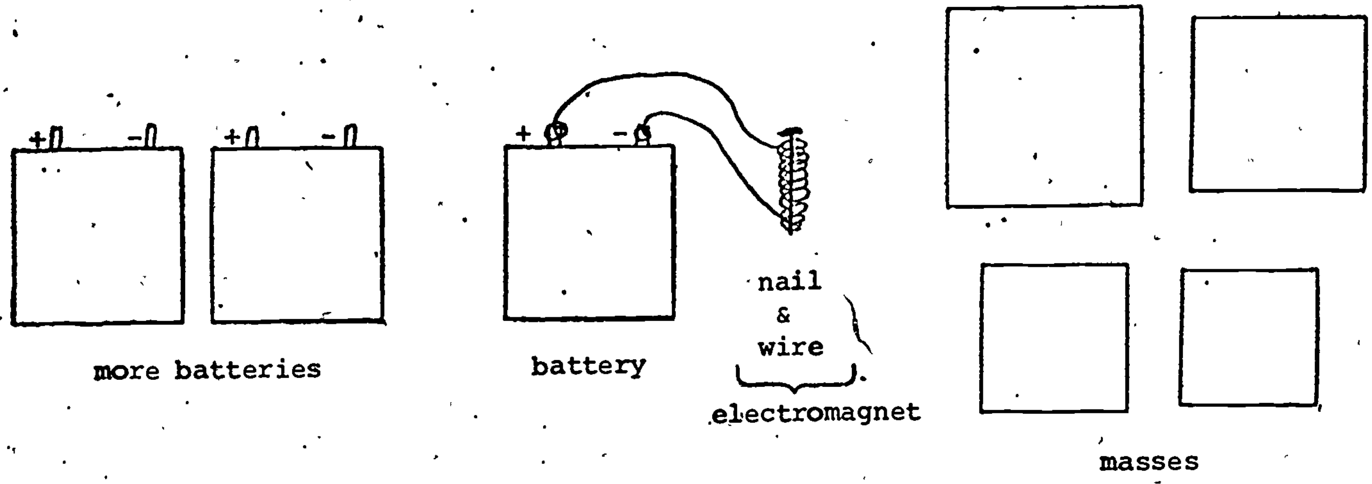
(d) What do you call your equipment?

(e) What are you doing with your equipment?

(f) How do you attract the largest mass?

7. Magnets (b)

Andy's teacher made an electromagnet by wrapping a wire around a nail. To power the magnet, she attached both ends of the wire to a battery. She could add another battery to the circuit each time she wanted to increase the power of the magnet. She also had a number of steel masses.



Directions: Suppose the teacher said she would try to answer a question for the class by doing an experiment. Which one do you think is best?

Circle the letter of your choice.

(a) How do you make the magnet pick up more mass?

(b) Can the electromagnet pick up all the masses?

(c) Does the amount of power in the circuit affect the mass the magnet can pick up?

(d) What can you do with an electromagnet?

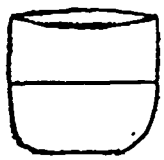
(e) What is an electromagnet?

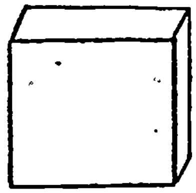
(f) Will the magnet pick up more mass if you add a battery to the circuit?

8. Solutions

Tim's teacher had a jar with water in it. She kept adding salt to the water and stirring it until it dissolved. After a while no more salt would dissolve. It settled on the bottom of the jar.

She also had a stand that would hold the water jar and a candle that would fit under it.





Directions: Suppose the teacher asked the class if they had questions that could be answered by doing an experiment. Which is the best question for Tim to ask?

Circle the letter of your choice.

(a) If you warm the water will more salt dissolve in it?

(b) What can you do with the salty water?

(c) Can you make more salt dissolve in the water?

(d) Does the temperature of the water affect the amount of water that will dissolve in it?

(e) How can you make more salt dissolve in the water?

(f) Do you call the liquid in the jar a salt solution?

9. Plant Requirements - Fertilizer

Andy wanted to grow some tomatoes. He decided to start them indoors in a pot. He was told he should add fertilizer to the pot.

Directions: Andy wondered about fertilizer. If Andy wanted to do an experiment, which would be the best question for Andy to ask?

Circle the letter of your choice.

(a) What is fertilizer?

(b) Can the plants grow faster?

(c) What is the fertilizer supposed to do?

(d) Will the plants grow faster if I give them fertilizer?

(e) How does the amount of fertilizer affect the growth of the plants?

(f) How can we make the plants grow faster?

10. Pendulum

Bill noticed the grandfather clock in the hall wasn't keeping good time. It was always slow. He wound it up but it still didn't keep good time. His dad told him the pendulum must be off.

Directions: Bill thought of a lot of questions. If he wanted to do an experiment, which is the best question for him to ask?

Circle the letter of your choice.

(a) Why does the clock need a pendulum?

(b) What is a pendulum?

(c) Can the pendulum be made to go faster?

(d) Will the pendulum go faster if I move the weight up and make the arm shorter?

(e) What can I do to the pendulum to make it speed up?

(f) Will moving the weight up or down the arm affect how fast or slow the clock runs?

11. Water and Heat

Gary was at the YMCA on Saturday. After a swim, he decided to go to the sauna. He had never been in a sauna. A man poured some water on some rocks at one end of the sauna room and the room got all steamy.

Directions: Gary wanted to understand what had happened. If he wanted to do an experiment, which is the best question for him to ask?

Circle the letter of your choice.

(a) Can I make more steam?

(b) Does the temperature of the rocks affect how much steam I get?

(c) What is a sauna bath?

(d) If I make the rocks hotter will I get more steam?

(e) What do I do to make more steam?

(f) What does the water on the rocks do?

B. DEVELOPING A PLAN - Junior Level

Answer Sheet

Items	Level 1	Level 2	Level 3	Level 4
1. Reflection	a	c	b	d
2. Solutions	c	b	d	a
3. Conducting Sound	b	d	c	a
4. Shadows	d	b	a	c
5. Animal Coverings - feathers	b	c	a	d
6. Pitch of Sound	c	a	b	d
7. Plant Requirements	a	d	c	b
8. Mass and Weight	c	a	d	b
9. Bicycle (a)	b	d	a	c
10. Bicycle (b)	d	c	b	a

Developing A Plan

1. Reflection

Molly was sleeping outdoors on a camping trip with her friends. Just before she went to sleep the moon came up. She could see their knapsacks in a row nearby. One or two seemed much clearer than the others. She even thought she could see the grass in front of them more clearly.

Back at school she asked her teacher about this. He told her to get four sheets of paper, one white, one orange, one green and one black. He told her to get also a small candle in a holder.

Directions: Here are some ideas about what Molly could do with this equipment. Which one do you think is best?

Circle the letter of your choice.

(a) Cut the sheets of paper into small squares. Glue all the little squares to a large sheet. Mix up the light and dark colours to make a pattern. Hang the large sheet on the wall. Light the candle and turn out all the other lights. See if the pattern looks nice in the dim light. Make another one to see if you like it better.

(b) Tape one of the sheets of paper to a wall in a large room. Put a little table beside the wall under the paper. Put some things on the table. Light the candle. Put it on a table in the middle of the room. Then turn out the lights. See how clearly you can see the table and the things on it. Repeat with each of the other sheets of paper. See if there are any differences in what you can see.

(c) Hang the 4 sheets of paper in a row on a wall in a large room. Light the candle and turn out all the other lights. Hold the candle in your hand. Look very carefully at each sheet of paper one at a time. Move the candle up and down, and back and forth. See if you can notice anything about the different papers. See if you can notice anything near the papers. Tell your teacher everything you saw.

(d) Put the candle on a table in the middle of the room. Put a ball on a table against a wall. Pile a few books in front of the ball to shade it from light from the candle itself. Tape each sheet of paper, one at a time, in the same place on the wall above. Light the candle. With each sheet, turn out the other lights. Stand to one side in the same place and see if you can see the ball better with one paper or another.

2. Solutions

Dave and his brother emptied the salt shaker in a glass of water one day. They stirred it, but a lot of the salt wouldn't dissolve. It settled on the bottom of the glass. They left the glass on the windowsill and went out to play. When they came back the sun was shining through the window on the glass. They stirred it again and now all the salt dissolved. Dave wanted to learn more. His mother gave him some empty jam jars and a box of salt.

Directions: Here are some ideas about what Dave might do with this equipment. Which one do you think is best?

Circle the letter of your choice.

(a) Put equal amounts of water in each jar. Each jar has a different temperature. Measure the temperature of the first jar. Add 5 mL of salt and stir it. Then add another 5 mL and stir. Keep doing this until no more salt will dissolve. Then do just the same things with the other jars. See in which temperature the most salt dissolves.

(b) Fill each jar with water from the tap. Sometimes use the cold water tap. Sometimes use the hot water tap. Sometimes mix hot and cold water. Take the temperature of the water in each jar if you want. Slowly pour salt into each jar. Stir it as you pour it. Watch carefully to see what happens as you pour and stir.

(c) Fill all the jam jars with water from the tap. Maybe you could use one jar to catch the water and pour from it into the other jars. Be careful not to spill water on the floor. Pour some salt into the jars. Stir them or shake them. Do this carefully. Taste the water in each jar. Keep adding more salt until it's all gone.

(d) Fill some jars with water from the cold water tap. Fill some from the hot water tap. Fill some with half hot, half cold water. Take the temperature of each jar if you like. Then put some salt, a little bit at a time, in each jar. Stir each time you do this. See how many times you can add salt to each jar. See which one tastes saltiest.

3. Conducting Sound

When Sandy was swimming underwater one day at the lake she heard a motor boat. It sounded different than from shore. She wondered about sound through air, water or solids. One day she got into the bathtub to find out more. She had a tuning fork to make a sound and she asked her sister to help her.

Directions: Here are some ideas about what Sandy could do. Which one is best?

Circle the letter of your choice.

(a) Get in the bathtub. Get her sister to practice using the same force each time she strikes the fork. Get her to strike the fork in the air, or under the water, or along the side of the tub, or along the wall. Listen sitting up in the tub, or lying underwater, or with her ear against the side of the tub or the wall, wherever her sister strikes the fork. See if the sounds are different. Make sure her sister uses a ruler so the fork is always the same distance from Sandy's ear.

(b) Get in the bathtub with her sister. Put the tuning fork in their little brother's toy rubber boat. Bang the tuning fork while they push the boat back and forth in the water. Maybe the boat will sink. If it does the tuning fork will hit the bottom of the tub. Put her ear down in the water very quickly so she hears the sound coming through the water.

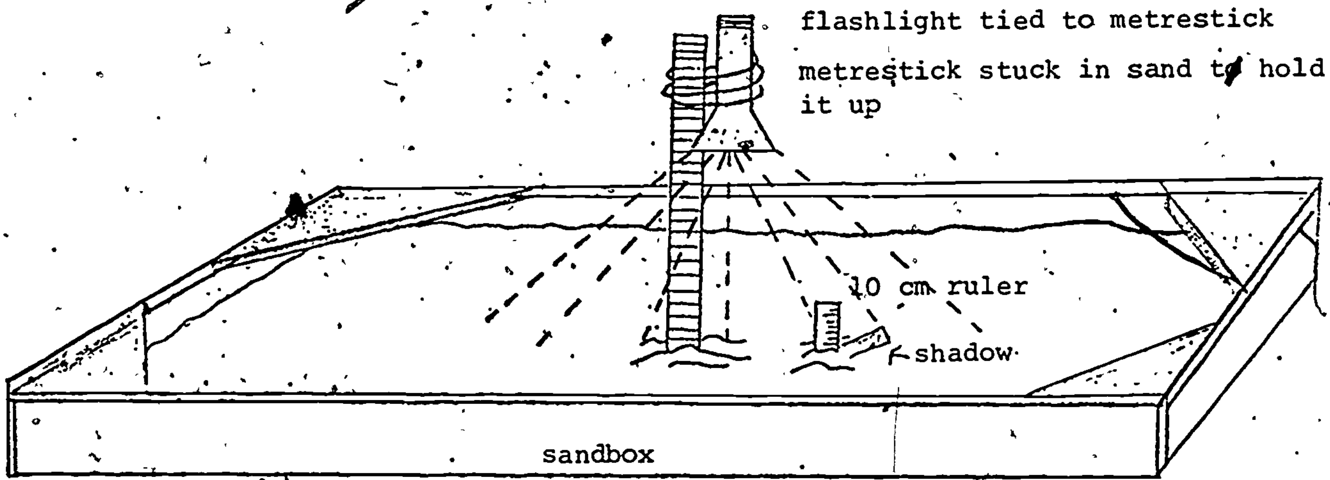
(c) Get in the bathtub. Get her sister to strike the tuning fork with a spoon. Get her to do this several times. Listen first sitting up in the tub. Then listen with her head underwater. Then listen with her ear against the side of the metal tub. Then listen with her ear against the wall. Do this many times to be sure she's done it right. Listen carefully each time and see if the sound is different.

(d) Get in the bathtub. Get her sister to stand different places in the bathroom. Get her to strike the tuning fork with a spoon. Sometimes put her head underwater and listen to see what happens. Get her sister to take a turn in the bathtub. Strike the tuning fork and let her sister listen. Try to think of different things to do to see what happens.

4. Shadows

Christine walked home one night from her friend's house. There was a streetlight on the corner. As she got closer her shadow seemed to change. It changed again when she passed the light and moved further away from it. She wanted to learn more about this.

This is the equipment she set up in a dark room.



Directions: Here are some ideas for what Christine might do with her equipment. Which one do you think is best?

Circle the letter of your choice.

(a) Stick the little ruler in the sand. Measure how far away from the metrestick it is. Also measure how long it's shadow is. Then move the little ruler farther away from the metrestick. Measure how far away it is this time. Measure how long the shadow is now. Do this many times until she's sure she's doing it right.

(b) Pretend the little ruler is herself walking home at night. Make it move slowly towards the light or away from the light. Or make it move quickly if she wants. Or do anything else she wants. Pay attention very carefully. Watch to see what happens to the shadow from the little ruler on the surface of the sand.

(c) Make the sand very level. Draw a straight line in the sand across the sandbox. Place the metrestick in the sand on this line. Starting 5 cm from the big ruler on the line and moving 5 cm away each time, push the little ruler 2 cm into the sand. Go both directions. Measure the shadow each time and compare the lengths. Stop if the shadow goes beyond the edge of the box.

(d) Pretend the little ruler is herself walking home at night. Make it run fast. Make it walk slowly. Make it hop and skip. Make it go around and around the streetlight (the big ruler). Get her friends to get little rulers too. Pretend their shadows are trying to catch each other.

5. Animal Coverings - Feathers

Bill went bird watching in the woods with his grandfather. Sometimes he could see a bird easily. Other times he had trouble seeing one even when his grandfather pointed it out. He wondered about this.

The next time they went to the woods they took a box full of different kinds of bird feathers with them.

Directions: Here are some ideas about what Bill might do with the feathers. Which one do you think is best?

Circle the letter of your choice.

(a) Pick out two groups of feathers. Make the feathers in one group plain colors and the feathers in the other group have stripes of different colors. Find some places in the woods where the sun comes through the trees in light and dark patches on the ground. Mix up the feathers. Toss them all on the ground in one of those places. See which ones are easiest to pick out.

(b) Pick out all the feathers he likes best. Tie a shoelace around his head. Stick some of the feathers in it. Hide from his grandfather among the trees. Hide among the rocks. See if his grandfather can spot him. If he wants, change the feathers and try again. If his grandfather can't spot him he wins the game.

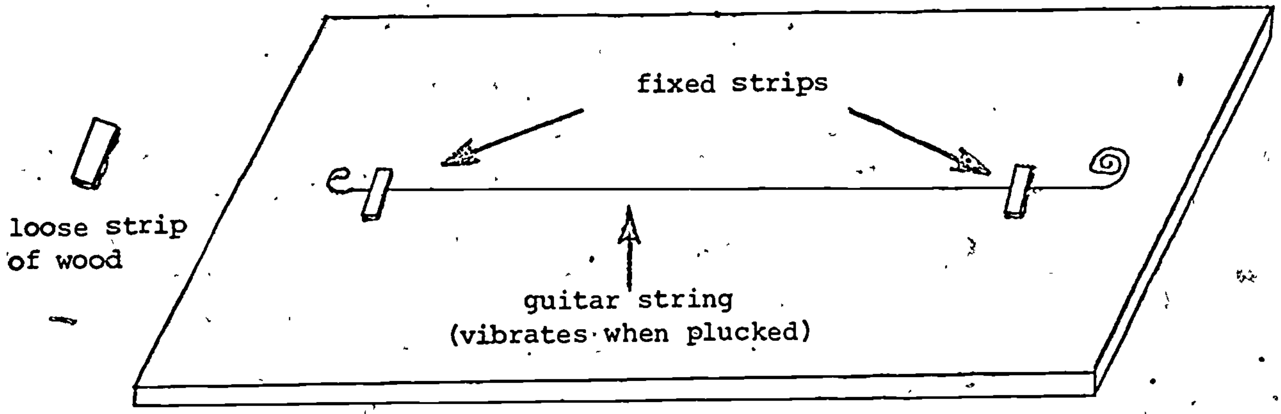
(c) Take some feathers and hold them up one at a time against a rock. Take some and hold them against a tree trunk. Hold some in front of some leafy branches, or between his eyes and a lake. Do it carefully several times. Try and find other places to hold the feathers. Pay attention to what happens and make notes.

(d) Choose some plain feathers and some striped feathers. Find a place where the sun is patchy on the ground. Get his grandfather to put them down one at a time, in mixed up order, in different spots with the same amount of light and shade. Don't look until he says "Ready". See how many seconds it takes to spot each one. Stop if the sun goes behind a cloud and wait until the light gets bright again.

6. Pitch of Sound

Paul listened to his father play a guitar. When his father plucked a string the sound was different if the fingers of his other hand pressed on the string close by or out towards the end of the guitar's neck. Paul wanted to learn more about this.

He and his father got a board and fastened a guitar string to it by nailing two little strips of wood across the string. He had another little strip of wood he could use for what guitar players call a "moveable bridge" if he wanted.



Directions: Here are some ideas about what Paul might do with his equipment. Which one do you think is best?

Circle the letter of your choice.

(a) Put his other little strip of wood across the string. Don't nail it down. Move it back and forth on the string while he plucks it. See if the strip of wood holds the string like his father's big fingers did. Watch the string vibrate (jiggle). See if anything else happens while he's doing that. Watch and listen carefully so he can learn something.

(b) Hold the other strip of wood across the string close to one of the pieces he nailed down. Pluck the string with a finger on his other hand. Watch the string vibrate (jiggle) and listen to the sound. Then move the loose strip a little further away, pluck the string again and listen for any change. Do this all across the string, moving the piece of wood each time. At the last the piece of string that vibrates as he plucks it will be very short.

(c) He has made himself a little musical instrument. Take turns with his friends plucking the string with their fingers. Watch the string vibrate (jiggle) and listen to the sound it makes. Hold the other little strip of wood across the string too if they want. Sing while they are doing it. Make up different songs.

(d) Attach a weight to the long loose end of the string. Let it hang over the edge of the board to keep the string tight at all times. Hold the loose strip of wood across the string 4 cm from one of the pieces he nailed down. Pluck the string and listen. Do this all across the board, moving the loose strip 4 cm each time. Pluck the same way each time. Listen carefully for any changes in the sound as the piece of string that can vibrate (jiggle) when it is plucked gets shorter and shorter.

7. Plant Requirements

John would like to be a gardener when he finishes school. He wants to learn how to care for plants. It's winter so he must work indoors. He has some flower pots and some soil. He also has some bean seeds. He knows seeds need water and he can get that from the tap.

Directions: Here are some ideas about what John might do. Which one do you think is best?

Circle the letter of your choice.

(a) Put soil in the flower pots. Plant the seeds. Plant about 10 seeds because some might not grow. Put one seed in each pot. Put the pots out of the way on some windowsills. Be sure they get some sunlight. Ask his mother to tell him when they need more water so he won't forget. If the plants grow beans pick them.

(b) Plant 10 bean seeds, one in each pot. Plant each at the same depth. Put all the pots in a place where they get the same amount of sunlight. Each day give 2 plants cold water, two cool water, two medium water, two warm water, and two hot water. Give each the same amount. Count the days until sprouts appear in each pot and compare them.

(c) Plant about 10 bean seeds, one in each pot. Place the pots around the room where they can get some light. Be sure to water the plants when they need it. Give them different temperatures of water. Give some pots cold, some cool, some medium, some warm and some hot water. Count the days until sprouts appear in each pot and compare them.

(d) Plant one bean seed in each pot. Plant about 10 altogether. Set them in places where they can get some light. Water them when they need it. Watch to see what happens if you give the plants different temperatures of water. Get different temperatures by taking water from the cold tap, the hot tap or both at once.

8. Mass and Weight

Steve helped his father clear rocks and stones from the beach at the cottage. He found a big one underwater. Although it was heavy, he could get it to the surface. But he couldn't lift it out. Steve was puzzled.

His father helped him collect a few small stones. They filled a pail with water from the lake. They borrowed a spring scale.

Directions: Here are some ideas for what Steve could do with his equipment. Which do you think is best?

Circle the letter of your choice.

(a) Tie a string around each stone. Hook each one to the scale and find its mass. Dip each stone in the water, still attached to the scale. See what you can notice. Jiggle it up and down in the water and see what happens.

(b) Tie a string around each stone. Attach one to the scale and find its mass. Be sure to hold his hand very steady. Dip the stone in the water just to the bottom of the hook. Hold it very steady and find its mass again. Repeat with more of the stones if he wants. Compare the masses of the stones when they are in and out of the water.

(c) Tie a string around each stone. Hook them to the scale with the string. See how many he can find the mass of at the same time. Drop the stones in the pail. Make a little underwater mountain with the stones.

(d) Tie a string around each stone. Hook a stone to the scale and find its mass. Add stones until the scale won't take any more. Then dip them into the water. See how many more he can add to the scale now.

9. Bicycles (a)

Peter was riding his bicycle downtown one day. He had to stop quickly when a big truck cut in front of him. A storekeeper who saw him was frightened. He scolded Peter. He said he was riding his bicycle too fast for safety in traffic.

Peter didn't like what he said. He asked his friends to bring their bicycles to the school yard on Saturday when no one was around. He set up a course with sticks at the starting line and finish line.

Directions: Here are some ideas for what Peter might do. Which one do you think is best?

Circle the letter of your choice.

(a) Take 3 people. Tell each person to start separately. Tell one person to ride fast, one person to ride slowly and one person to go at an in between speed. Stand at the finish line. See how long it takes each one to stop when they put on their brakes at the finish line and compare the times.

(b) Line up everybody at the starting line. Say "go". Watch them pedal as fast as they can. Yell "stop" when they get to the end of the course. Tell them not to put on their brakes too hard in case they skid and fall over. The winner is the first one to get to the finish line and get stopped safely.

(c) Ask one person to ride the same bicycle three times at different speeds. Be careful he starts at the same place each time and puts on his brakes at the same place. Measure how many seconds it takes him to stop at each speed and compare the times. Ask each of the others to do the same thing. Compare the stopping time at different speeds for them also.

(d) Line up everybody at the starting line. Tell some of them to go fast. Tell some to go slowly. Tell others to go at an in between speed. Tell everybody to put on their brakes when they get to the finish line. Watch carefully to see what happens. Tell them all to be careful when they put on their brakes.

10. Bicycles (b)

Terry and his bigger brother ride their bicycles to school each day. There is a long hill on the way. Terry's brother can always coast farther at the bottom of the hill than Terry can.

Terry asked his friends to bring their bicycles to the hill one day after school. Jim's mass is 35 kg, Eric's mass is 38 kg and Terry is biggest. His mass is 41 kg.

Directions: Here are some ideas for what Terry and his friends could do. Which on do you think is best?

Circle the letter of your choice.

(a) If the bikes aren't the same each boy uses the same one to ride down the hill. Each boy makes a still start at the same spot. Each boy stops pedaling at the same spot. Measure who coasts the farthest after he stops pedaling.

(b) One person at a time pedals down the hill. He stops pedaling at the bottom. One of the others measures how far he coasts after he stops pedaling. See who coasts the farthest.

(c) Start together down the hill. Be sure there isn't any traffic coming so it's safe. Stop pedaling close to the bottom. Ask somebody to watch each of them and tell them what he sees.

(d) Have a race down the hill. Do it several times. Start at the top of the hill sometimes. Start halfway down sometimes. Stop when it's time to go home for dinner.

C. JUDGING THE ADEQUACY OF DATA - Junior Level

Answer Sheet

1. c
2. a
3. c
4. a
5. d

6. b
7. b
8. d
9. c
10. b

11. d
12. d
13. b
14. c
15. a

16. a
17. c
18. b
19. c

20. a
21. b
22. c
23. a
24. c

25. b
26. b
27. a
28. c
29. c

30. a
31. d
32. c
33. a
34. b

35. c
36. c
37. d

Judging The Adequacy of Data

1. When measuring mass which instrument would give you more accurate results? One marked in:

   (a) kilograms

   (b) grams

   (c) milligrams

   (d) none of these

2. When measuring distance which instrument would give a more accurate result? One marked in:

   (a) millimetres

   (b) centimetres

   (c) kilometres

   (d) none of these

3. The most accurate measurement of time would be obtained by using:

   (a) a clock with a second hand

   (b) a wristwatch with a second hand

   (c) a stop watch

   (d) none of these

4. A__________________________________B

   While placing a ruler on the line segment AB before measuring the distance from A to B, it is more accurate to be looking straight down the ruler with your eyes directly above:

   (a) point A

   (b) point B

   (c) the centre of the line segment

   (d) none of these

5. You have planted three bean sprouts in an experiment to find out how much they will grow in a month. At the end of a month your best answer would be obtained by:

(a) measuring the tallest plant

(b) measuring the shortest plant

(c) measuring the middle plant

(d) measuring all three and averaging their heights

6. When comparing the mass of two similar objects your best answer would be obtained by:

(a) holding one in each hand to feel the difference

(b) using an equal arm balance

(c) using bathroom scales

7. If you wanted to measure the volume of a marble by placing it in water, you would get a more accurate answer by using:

(a) a wide, graduated cylinder

(b) a narrow, graduated cylinder

(c) either one would give an equally accurate answer

8. When doing any experiment, your most accurate result will be obtained by doing the experiment:

(a) once, working very carefully

(b) twice and averaging results

(c) three times and averaging results

(d) many times and averaging results

9. When measuring the circumference (i.e., the distance around) of a wheel the most accurate answer would be obtained by:

(a) stretching a tape measure around the wheel

(b) rolling the wheel one complete turn along the ground and measuring the distance it has travelled in a straight line

(c) measuring the diameter of the wheel and using the mathematical formula ($C = \pi d$) for finding the circumference

10. The most accurate way to record information from reading research is to:

(a) put the facts down in point form

(b) use a direct quotation from the text book

(c) record the facts in your own words

11. The best way to find out about the covering of an animal is to:

(a) read a description of it in your text book

(b) look at a picture of the animal

(c) study a labelled diagram of the animal

(d) examine a live specimen of the animal

12. What would be the best unit of measurement to use when measuring the distance from Peterborough to Toronto?

(a) millimetre

(b) centimetre

(c) metre

(d) kilometre

13. What would be the best unit of measurement to use when measuring the length of a soccer field?

(a) millimetre

(b) metre

(c) kilometre

(d) centimetre

14. What would be the best unit of measurement to use when measuring the length of your desk?

(a) metre

(b) kilometre

(c) centimetre

(d) millimetre

15. What would be the best unit of measurement to use when measuring the width of your eraser?

(a) millimetre

(b) centimetre

(c) kilometre

(d) metre

16. What would be the best unit of measurement to use when measuring your mass?

(a) kilograms

(b) grams

(c) milligrams

17. What would be the best unit of measurement to use when measuring the mass of an apple?

(a) milligrams

(b) kilograms

(c) grams

18. Three bicycles are going to be tested for manoeuvrability around an obstacle course. What would be the best way of conducting the test?

(a) have a different person ride each bicycle

(b) have one person ride all three bicycles

(c) make sure all the riders are boys

(d) make sure all the riders are girls

19. If you were to measure the length of your schoolyard, which of the following instruments would give the most accurate answer?

(a) 30 cm ruler

(b) planimeter

(c) 100 m tape

(d) 10 m tape

20. When measuring the volume of a cube, the most accurate answer will be obtained by:

(a) measuring the length of the sides and using the mathematical formula (V = L x W x H)

(b) placing the cube in a narrow graduated cylinder and measuring the amount the water rises

(c) placing the cube in a wide graduated cylinder and measuring the amount the water rises

(d) placing the cube in a beaker filled to the brim with water and measuring the amount of water which overflows

21. When describing the temperature of a liquid, which of the following gives the information most accurately?

(a) hot

(b) 31°C

(c) warm

(d) boiling

22. When describing the mass of an object, which of the following gives the information most accurately?

(a) light

(b) heavy

(c) 50 kg

23. Pick out the most accurate term for describing the distance from one point to another.

(a) 20 m

(b) short

(c) long

24. When describing the speed at which an object is travelling, which term would give the most accurate description?

(a) fast

(b) slow

(c) 30 km per hour

(d) quickly

25. If you were giving a scientific description of a bird's feather, which of the following words would you not use?

(a) long

(b) pretty

(c) smooth

(d) blue

26. Which one of the descriptions of a desk has unnecessary information?

(a) brown coloured, 3 drawers, rectangular shape

(b) rectangular shape, 70 cm x 140 cm dimensions, located in middle of room

(c) brown colour, slanted top, round legs

(d) square legs, rectangular shape, brown colour

27. Which one of the descriptions of a rug has unnecessary information?

(a) rectangular shaped, plain colour, has fringe on side, is located by the door

(b) oval shaped, silk fringe on the side, red coloured, has a spot of grease on the side

(c) square, red, shag, fringed

(d) round shaped, blue and white coloured, emblem in centre

28. Which one of the descriptions of a plant has unnecessary information?

(a) long stems, very leafy, golden coloured flower, 1 m high

(b) short stem, oval shaped leaves, flowers are red and clustered

(c) long stems, very bushy, in a wooden pot, blue flowers

(d) alternating leaf pattern, long stems, no flowers, 2 m high

29. Which of the descriptions of a fish has unnecessary information?

(a) 32 cm long, found in tropical seas, yellow and blue in colour

(b) fresh water fish, light and dark green stripes, whitish belly, 20 cm long

(c) in a 2 L tank, grey and green in colour, very long thin body

(d) has many sharp teeth, very broad head, white belly, green back

30. Which one of the descriptions of a deer has unnecessary information?

(a) white tail, large antlers, 120 kilograms in weight, found north of Omemee

(b) white tail, small furry antlers, white spots on back, white breast

(c) a female, no antlers, white tail, brown body colour

(d) five pronged antlers, large muscular chest, white tail, 200 kilograms

31. Which one of the descriptions of an animal has unnecessary information?

(a) bushy tail, 70 kilograms in weight, scruffy ears, large fangs

(b) large fangs, shaggy fur, grey in colour, bushy tail

(c) brown eyes, shaggy fur, large padded feet, broad flat head

(d) broad flat head, bushy tail, looks hungry, scruffy ears

32. Which method of timing would be more accurate when measuring the time of a runner in a 100 m sprint?

(a) when the starter is also the timer

(b) when one person starts and another times

(c) when two people time the runner and average the results

(d) when there are 3 different timers and the best time is taken

33. Which method of measuring would be best if you were measuring the distance that a bicycle could coast down a gentle slope from a standing start?

(a) measure from where the back wheel starts to where the back wheel stops

(b) measure from where the back wheel starts to where the front wheel stops

(c) measure from the spot the rider starts to where the rider stops

(d) any of the methods above would be the same

34. If a sprinting race was being started by a judge at the finishing line 300 metres away, which method would be the best for starting the race?

(a) by yelling the signal ready-set-go

(b) using a hand signal to start

(c) using a starting pistol as a signal to go

35. Bill wanted to know if all bean seeds have the same mass. He should use a balance which can be read to the nearest:

(a) gram

(b) kilogram

(c) 0.1 gram

(d) milligram = 0.001 gram

36. Jim wanted to measure the daily growth of a newly germinated bean seed. He should use a ruler which can be read to the nearest:

(a) metre

(b) centimetre

(c) millimetre

(d) 0.5 centimetres

37. Bob and Anne were measuring the weight of a piece of metal using spring scales. They recorded their values in the table below.

Trial	Anne's Measurements	Bob's Measurements
1	5.0 N	4.8 N
2	4.9 N	4.7 N
3	5.0 N	4.8 N
4	5.1 N	4.9 N
5	5.0 N	4.8 N
Average	5.0 N	4.8 N

Which of the following factors might account for the different answers.

(a) one of the spring scales was not "zeroed" (reading zero) at the beginning of the measurement

(b) either Anne or Bob was not reading the scale at eye level

(c) one of the spring scales has lost some of the "tightness" of its coils

(d) possibly any of the above

D. RECORDING INFORMATION - Junior Level

Answer Sheet - Version 1

1. Ramp	(a)
2. Vinegar and Soda	(c)
3. Coasting Distance	(a)
4. Plant Requirements - soil type	(e)
5. Plant Requirements - water temperature	(b)
6. Mass and Volume	(d)

Answer Sheet - Version 2

	Items 1	2	3	4
1. Ramp	(iii)	(iii)	(ii)	(ii)
2. Vinegar and Soda	(ii)	(iv)	(iii)	(iv)
3. Coasting Distance	(ii)	(iv)	(iv)	(ii)
4. Plant Requirements - soil type	(i)	(iv)	(iv)	(ii)
5. Plant Requirements - water temperature	(i)	(iv)	(iv)	(ii)
6. Mass and Volume	(i)	(iv)	(iv)	(i)

Note: Students must choose the correct answer to all 4 questions to score correct on each item.

Answer Sheet - Version 3

1. Ramp	See option (a), version 1
2. Vinegar and Soda	See option (c), version 1
3. Coasting Distance	See option (a), version 1
4. Plant Requirements - soil type	See option (e), version 1
5. Plant Requirements - water temperature	See option (b), version 1
6. Volume and Mass	See option (d), version 1

1. Effect of Height of Ramp on Distance a Marble Rolls (Version 1)

Richard built a ramp and rolled a marble down it to see how far it would travel across the floor. He then decided to find out if the distance travelled by a marble is influenced by the height of the ramp. He rolled 3 marbles down the ramp when it was 10 cm high. Then he rolled the same 3 marbles from ramps 20 cm high and 30 cm high. He was careful to do everything the same each time he started a marble down the ramp.

Here is the information Richard collected.

Height of Ramp		Colour of Marble	Distance Rolled	Length of Time the Marble Rolled
10 cm	1st marble	blue	60 cm	1.0 s
20 cm	1st marble	blue	120 cm	1.5 s
30 cm	1st marble	blue	240 cm	2.0 s
10 cm	2nd marble	red	120 cm	1.5 s
20 cm	2nd marble	red	240 cm	2.0 s
30 cm	2nd marble	red	360 cm	2.5 s
10 cm	3rd marble	yellow	240 cm	2.0 s
20 cm	3rd marble	yellow	360 cm	2.5 s
30 cm	3rd marble	yellow	480 cm	3.0 s

Directions: Which of the following charts should he use to answer the question: Does the height of the ramp affect the distance that the marble rolls?

Circle the letter of the correct answer.

(a)

Height of Ramp	Distance Rolled: 1st marble	2nd marble	3rd marble
10 cm	60 cm	120 cm	240 cm
20 cm	120 cm	240 cm	360 cm
30 cm	240 cm	360 cm	480 cm

(b)

Height of Ramp	Distance Rolled: 1st marble	3rd marble
10 cm	60 cm	240 cm
20 cm	120 cm	360 cm
30 cm	240 cm	480 cm

(c)

	Height of Ramp	Distance Rolled	Time Taken
1st marble	10 cm	60 cm	1.0 s
1st marble	20 cm	120 cm	1.5 s
1st marble	30 cm	240 cm	2.0 s
2nd marble	10 cm	120 cm	1.5 s
2nd marble	20 cm	240 cm	2.0 s
2nd marble	30 cm	360 cm	2.5 s
3rd marble	10 cm	240 cm	2.0 s
3rd marble	20 cm	360 cm	2.5 s
3rd marble	30 cm	480 cm	3.0 s

(d)

	Height of Ramp	Time Taken to Roll
1st marble	10 cm	1.0 s
1st marble	20 cm	1.5 s
1st marble	30 cm	2.0 s
2nd marble	10 cm	1.5 s
2nd marble	20 cm	2.0 s
2nd marble	30 cm	2.5 s
3rd marble	10 cm	2.0 s
3rd marble	20 cm	2.5 s
3rd marble	30 cm	3.0 s

(e)

Marble	Height of Ramp
1st	10 cm
1st	20 cm
1st	30 cm
2nd	10 cm
2nd	20 cm
2nd	30 cm
3rd	10 cm
3rd	20 cm
3rd	30 cm

Marble	Distance Rolled
1st	60 cm
1st	120 cm
1st	240 cm
2nd	120 cm
2nd	240 cm
2nd	360 cm
3rd	240 cm
3rd	360 cm
3rd	480 cm

1. Effect of Height of Ramp on Distance a Marble Rolls (Version 2)

Richard built a ramp and rolled a marble down it to see how far it would travel across the floor. He then decided to find out if the distance travelled by a marble is influenced by the height of the ramp. He rolled 3 marbles down the ramp when it was 10 cm high. Then he rolled the same 3 marbles from ramps 20 cm high and 30 cm high. He was careful to do everything the same each time he started a marble down the ramp.

Here is the information Richard collected.

Height of Ramp		Colour of Marble	Distance Rolled	Length of Time the Marble Rolled
10 cm	1st marble	blue	60 cm	1.0 s
20 cm	1st marble	blue	120 cm	1.5 s
30 cm	1st marble	blue	240 cm	2.0 s
10 cm	2nd marble	red	120 cm	1.5 s
20 cm	2nd marble	red	240 cm	2.0 s
30 cm	2nd marble	red	360 cm	2.5 s
10 cm	3rd marble	yellow	240 cm	2.0 s
20 cm	3rd marble	yellow	360 cm	2.5 s
30 cm	3rd marble	yellow	480 cm	3.0 s

Directions: Richard drew up the following chart to help him answer the question: Does the height of the ramp affect the distance that the marbles rolls?

Height of Ramp	Distance Rolled: 1st marble	2nd marble	3rd marble
10 cm (j)	(a)	(b)	(c)
20 cm (k)	(d)	(e)	(f)
30 cm (l)	(g)	(h)	(i)

1. How should he record the information that the 2nd marble rolled from a height of 20 cm took 2.0 s to come to a stop?

Circle the number of the correct answer.

(i) Put 2.0 s in space (e).

(ii) Put 2.0 s in spaces (b), (e), and (h).

(iii) Leave it out.

(iv) Make up a new space for the information.

2. How should he record the colours of the 3 marbles?

Circle the number of the correct answer.

(i) Put the colours in spaces (a), (b), and (c).

(ii) Put the colours in spaces (a), (d), and (g).

(iii) Leave it out.

(iv) Make up new spaces for the information.

3. How should he record the information that the 3rd marble rolled 480 cm from the 30 cm ramp?

Circle the number of the correct answer.

(i) Put 480 cm in space (c).

(ii) Put 480 cm in space (i).

(iii) Leave it out.

(iv) Make up a new space for the information.

4. How should he record the distances rolled by the 1st marble?

Circle the number of the correct answer.

(i) Put the distances rolled in spaces (a), (b), and (c).

(ii) Put the distances rolled in spaces (a), (d), and (g).

(iii) Leave it out.

(iv) Make up new spaces for the information.

1. Effect of Height of Ramp on Distance a Marble Rolls (Version 3)

Richard built a ramp and rolled a marble down it to see how far it would travel across the floor. He then decided to find out if the distance travelled by a marble is influenced by the height of the ramp. He rolled 3 marbles down the ramp when it was 10 cm high. Then he rolled the same 3 marbles from ramps 20 cm high and 30 cm high. He was careful to do everything the same each time he started a marble down the ramp.

Here is the information Richard collected.

Height of Ramp		Colour of Marble	Distance Rolled	Length of Time the Marble Rolled
10 cm	1st marble	blue	60 cm	1.0 s
20 cm	1st marble	blue	120 cm	1.5 s
30 cm	1st marble	blue	240 cm	2.0 s
10 cm	2nd marble	red	120 cm	1.5 s
20 cm	2nd marble	red	240 cm	2.0 s
30 cm	2nd marble	red	360 cm	2.5 s
10 cm	3rd marble	yellow	240 cm	2.0 s
20 cm	3rd marble	yellow	360 cm	2.5 s
30 cm	3rd marble	yellow	480 cm	3.0 s

Directions: Use the above information to fill in this chart so that Richard can answer his question: Does the height of the ramp affect the distance that the marble rolls?

Add more rows and columns if you need them.

Distance Rolled

Height of Ramp	1st marble	2nd marble	3rd marble

2. Effect of Strength of Vinegar Mixed with Soda on Speed of a Toy Boat (Version 1)

Paul has a toy boat that uses a mixture of vinegar and baking soda for its power source. He wants to know if the strength of the vinegar he adds to a given amount of soda will affect the speed of the boat. He sets out a 1 metre course in a swimming pool. He uses 3 vinegar mixtures, weak, medium and strong, and measures the time it takes his boat to run the 1 metre course with each. He is careful to keep everything the same on each run except the strength of the vinegar mixture.

Here is all the information Paul collected.

Strength of Vinegar Mixture	Amount of Soda	Length of Course	Time of Run in Seconds		Levelness of Moving Boat	Length of Time Boat Runs Before Stopping (in seconds)
Weak:						
- 0.001 L water to .001 L vinegar	1 g	1 m	1st run	14	level	24
- 0.001 L water to .001 L vinegar	1 g	1 m	2nd run	15	level	26
- 0.001 L water to .001 L vinegar	1 g	1 m	3rd run	16	level	25
Medium:						
- 0.001 L water to .004 L vinegar	1 g	1 m	1st run	11	almost level	19
- 0.001 L water to .004 L vinegar	1 g	1 m	2nd run	10	almost level	19
- 0.001 L water to .004 L vinegar	1 g	1 m	3rd run	9	almost level	20
Strong:						
- vinega[illegible]o no wate[illegible]	1 g	1 m	1st run	4	bow up higher	15
- vinegar [illegible] no water	1 g	1 m	2nd run	5	bow up higher	15
- vinegar to no water	1 g	1 m	3rd run	6	bow up higher	15

Directions: Which of the following charts should he use to answer the question, "Does the strength of the vinegar in the vinegar-soda mixture affect the speed of the boat?"

Circle the letter of the correct answer.

(a)

	Time in Seconds
Weak mixture	15
Medium mixture	10
Strong mixture	5

(b)

	Time in Seconds Trial 1	Trial 2	Trial 3	Duration of Run (in seconds)
Weak mixture	14	15	16	25
Medium mixture	11	10	9	20
Strong mixture	4	5	6	15

(c)

	Time in Seconds Trial 1	Trial 2	Trial 3
Weak mixture	14	15	16
Medium mixture	11	10	9
Strong mixture	4	5	6

(d)

	Time in Seconds Trial 1	Trial 2	Trial 3
Weak Mixture	14	15	16

	Time in Seconds Trial 1	Trial 2	Trial 3
Medium Mixture	11	10	9

	Time in Seconds Trial 1	Trial 2	Trial 3
Strong Mixture	4	5	6

(e)

	Levelness of Moving Boat	Duration of Run (in seconds)
Weak Mixture	level	25
Medium Mixture	almost level	20
Strong Mixture	bow up higher	15

2. Effect of Strength of Vinegar Mixed with Soda on Speed of a Toy Boat (Version 2)

Paul has a toy boat that uses a mixture of vinegar and baking soda for its power source. He wants to know if the strength of the vinegar he adds to a given amount of soda will affect the speed of the boat. He sets out a 1 metre course in a swimming pool. He uses 3 vinegar mixtures, weak, medium and strong, and measures the time it takes his boat to run the 1 metre course with each. He is careful to keep everything the same on each run except the strength of the vinegar mixture.

Here is all the information Paul collected.

Strength of Vinegar Mixture	Amount of Soda	Length of Course	Time of Run in Seconds		Levelness of Moving Boat	Length of Time Boat Runs Before Stopping (in seconds)
Weak:						
- 0.001 L water to .001 L vinegar	1 g	1 m	1st run	14	level	24
- 0.001 L water to .001 L vinegar	1 g	1 m	2nd run	15	level	26
- 0.001 L water to .001 L vinegar	1 g	1 m	3rd run	16	level	25
Medium:						
- 0.001 L water to .004 L vinegar	1 g	1 m	1st run	11	almost level	19
- 0.001 L water to .004 L vinegar	1 g	1 m	2nd run	10	almost level	19
- 0.001 L water to .004 L vinegar	1 g	1 m	3rd run	9	almost level	20
Strong:						
- vinegar to no water	1 g	1 m	1st run	4	bow up higher	15
- vinegar to no water	1 g	1 m	2nd run	5	bow up higher	15
- vinegar to no water	1 g	1 m	3rd run	6	bow up higher	15

Directions: Paul prepared the following diagram to record the information so he would be able to answer his question: "Does the strength of the vinegar in the vinegar-soda mixture affect the speed of the boat?".

	Time of 1 metre run in seconds		
Strength of Mixture	1st run	2nd run	3rd run
weak mixture (j)	(a)	(b)	(c)
medium mixture (k)	(d)	(e)	(f)
strong mixture (l)	(g)	(h)	(i)

1. How should Paul record the information that on the 3rd runs the toy boat took 16 s with the weak mixture, 9 s with the medium mixture and 6 s with the strong mixture?

   Circle the number of the correct answer.

   (i) Put the numbers in spaces (a), (b) and (c).

   (ii) Put the numbers in spaces (c), (f) and (i).

   (iii) Make up new spaces for the information.

   (iv) Leave it out.

2. How should Paul record the information that the boat ran 26 s on the 2nd run using a weak mixture?

   Circle the number of the correct answer.

   (i) Include it in space (b).

   (ii) Include it in spaces (d), (e) and (f).

   (iii) Make up new spaces for the information.

   (iv) Leave it out.

3. How should Paul record the information that the 2nd run of the toy boat using the strong mixture took 5 s?

   Circle the number of the correct answer.

   (i) Put 5 s in space (e).

   (ii) Put 5 s in space (h).

   (iii) Make up a new space for the information.

   (iv) Leave it out.

4. How should Paul record the information that he used 1 g of soda each time he prepared a mixture?

Circle the number of the correct answer.

(i) Record it in spaces (j), (k) and (l) in the strength of mixture column.

(ii) Record it in each of the spaces (a), (b), (c), (d), (e), (f), (g), (h) and (i).

(iii) Make up new spaces for the information.

(iv) Leave it out.

2. Effect of Strength of Vinegar Mixed with Soda on Speed of a Toy Boat (Version 3)

Paul has a toy boat that uses a mixture of vinegar and baking soda for its power source. He wants to know if the strehgth of the vinegar he adds to a given amount of soda will affect the speed of the boat. He sets out a 1 metre course in a swimming pool. He uses 3 vinegar mixtures, weak, medium and strong, and measures the time it takes his boat to run the 1 metre course with each. He is careful to keep everything the same on each run except the strength of the vinegar mixture.

Here is all the information Paul collected.

Strength of Vinegar Mixture	Amount of Soda	Length of Course	Time of Run in Seconds		Levelness of Moving Boat	Length of Time Boat Runs Before Stopping (in seconds)
Weak:						
- 0.001 L water to .001 L vinegar	1 g	1 m	1st run	14	level	24
- 0.001 L water to .001 L vinegar	1 g	1 m	2nd run	15	level	26
- 0.001 L water to .001 L vinegar	1 g	1 m	3rd run	16	level	25
Medium:						
- 0.001 L water to .004 L vinegar	1 g	1 m	1st run	11	almost level	19
- 0.001 L water to .004 L vinegar	1 g	1 m	2nd run	10	almost level	19
- 0.001 L water to .004 L vinegar	1 g	1 m	3rd run	9	almost level	20
Strong:						
- vinegar to no water	1 g	1 m	1st run	4	bow up higher	15
- vinegar to no water	1 g	1 m	2nd run	5	bow up higher	15
- vinegar to no water	1 g	1 m	3rd run	6	bow up higher	15

Directions: Use the information to fill in this chart so that Paul can answer his question: "Does the strength of the vinegar in the vinegar-soda mixture affect the speed of the boat?"

Add more rows and columns if you need them.

Time of 1 m Run in Seconds

Strength of Mixture	1st run	2nd run	3rd run
Weak			
Medium			
Strong			

3. Effect of Cyclist's Mass on Distance He Can Coast (Version 1)

Jim is trying to find out why some children can coast further on their bicycles than others can. He wants to know whether a person's mass influences the distance he or she can coast. To find out, he gathered four of his classmates, Bill, Jane, Terry and Phyllis, who all had the same kind of bicycles, at the top of a hill near the school.

One at a time each started downhill by pushing off with his foot. Jim measured how far each travelled before needing to pedal to keep the bike balanced. Each friend did this three times and then Jim used the school nurse's scale to find their mass and height.

Here is the information Jim collected.

Student		Starting Point	Pedalled at Start	Distance Travelled when Started to Pedal	Type of Bicycle	Mass	Height	Boy or Girl
Bill	1st try	top of hill	no	300 m	10 speed Sekine	35 kg	1.3 m	Boy
	2nd try	top of hill	no	290 m	10 speed Sekine			
	3rd try	top of hill	no	290 m	10 speed Sekine			
Jane	1st try	top of hill	no	320 m	10 speed Sekine	36 kg	1.2 m	Girl
	2nd try	top of hill	no	320 m	10 speed Sekine			
	3rd try	top of hill	no	320 m	10 speed Sekine			
Terry	1st try	top of hill	no	330 m	10 speed Sekine	41 kg	1.5 m	Boy
	2nd try	top of hill	no	331 m	10 speed Sekine			
	3rd try	top of hill	no	331 m	10 speed Sekine			
Phyllis	1st try	top of hill	no	328 m	10 speed Sekine	38 kg	1.1 m	Girl
	2nd try	top of hill	no	327 m	10 speed Sekine			
	3rd try	top of hill	no	328 m	10 speed Sekine			

Directions: Jim and his friends tried to organize the information into a chart. Which one would best help Jim to answer his question, "Does a person's mass make a different to the distance he or she can coast on a bicycle?"

Circle the letter of the correct answer.

(a) Distance Travelled

Mass	1st Try	2nd Try	3rd Try
35 kg	300 m	290 m	290 m
36 kg	320 m	320 m	320 m
38 kg	328 m	327 m	328 m
41 kg	330 m	331 m	331 m

(b) Distance Travelled

	1st Try	2nd Try	3rd Try
Bill	300 m	290 m	290 m
Jane	320 m	320 m	320 m
Phyllis	328 m	327 m	328 m
Terry	330 m	331 m	331 m

	Mass
Bill	35 kg
Jane	36 kg
Phyllis	38 kg
Terry	41 kg

(c)

Mass	Height
35 kg	1.3 m
36 kg	1.2 m
38 kg	1.1 m
41 kg	1.5 m

(d) Distance Travelled

Mass	1st Try	2nd Try	3rd Try	Height
35 kg	300 m	290 m	290 m	1.3 m
36 kg	320 m	320 m	320 m	1.2 m
38 kg	328 m	327 m	328 m	1.1 m
41 kg	330 m	331 m	331 m	1.5 m

(e) Distance Travelled

Mass	1st Try	2nd Try	3rd Try
35 kg	300 m	290 m	290 m
41 kg	330 m	331 m	331 m

3. Effect of Cyclist's Mass on Distance He Can Coast (Version 2)

Jim is trying to find out why some children can coast further on their bicycles than others can. He wants to know whether a person's mass influences the distance he or she can coast. To find out, he gathered four of his classmates, Bill, Jane, Terry and Phyllis, who all had the same kind of bicycles, at the top of a hill near the school.

One at a time each started downhill by pushing off with his foot. Jim measured how far each travelled before needing to pedal to keep the bike balanced. Each friend did this three times and then Jim used the school nurse's scale to find their mass and height.

Here is the information Jim collected.

Student		Starting Point	Pedalled at Start	Distance Travelled when Started to Pedal	Type of Bicycle	Mass	Height	Boy or Girl
Bill	1st try	top of hill	no	300 m	10 speed Sekine	35 kg	1.3 m	Boy
	2nd try	top of hill	no	290 m	10 speed Sekine			
	3rd try	top of hill	no	290 m	10 speed Sekine			
Jane	1st try	top of hill	no	320 m	10 speed Sekine	36 kg	1.2 m	Girl
	2nd try	top of hill	no	320 m	10 speed Sekine			
	3rd try	top of hill	no	320 m	10 speed Sekine			
Terry	1st try	top of hill	no	330 m	10 speed Sekine	41 kg	1.5 m	Boy
	2nd try	top of hill	no	331 m	10 speed Sekine			
	3rd try	top of hill	no	331 m	10 speed Sekine			
Phyllis	1st try	top of hill	no	328 m	10 speed Sekine	38 kg	1.1 m	Girl
	2nd try	top of hill	no	327 m	10 speed Sekine			
	3rd try	top of hill	no	328 m	10 speed Sekine			

Directions: Jim and his friends made up the following chart to record the information that would help them answer their question: "Does a person's mass make a difference to the distance he or she can coast on a bicycle?"

Person's Mass		Distance Travelled Before Pedalling: First Time	Second Time	Third Time
Bill	(m)	(a)	(b)	(c)
Jane	(n)	(d)	(e)	(f)
Phyllis	(o)	(g)	(h)	(i)
Terry	(p)	(j)	(k)	(l)

1. How should they record the information that Bill had gone 300 m on his first try when he had to start pedalling.

   Circle the number of the correct answer.

   (i) Put 300 m in space (c).

   (ii) Put 300 m in space (a).

   (iii) Make up a new space for the information.

   (iv) Leave it out.

2. How should they record the information that each of the 4 persons used a 10 speed Sekine bicycle?

   Circle the number of the correct answer.

   (i) Record it in the spaces (m), (n), (o), (p).

   (ii) Record it in the spaces (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k) and (l).

   (iii) Make up new spaces for the information.

   (iv) Leave it out.

3. How should they record the information that Terry was 1.5 m tall?

   Circle the number of the correct answer.

   (i) Record it in space (g).

   (ii) Record it in space (p).

   (iii) Make up a new space for the information.

   (iv) Leave it out.

4. How should they record the information that Bill went 300 m, Jane 320 m, Phyllis 328 m and Terry 330 m on their first tries?

   Circle the number of the correct answer.

   (i) Put the numbers in spaces (b), (e), (h) and (k).

   (ii) Put the numbers in the spaces (a), (d), (g) and (j).

   (iii) Make up new spaces for the information.

   (iv) Leave it out.

3. Effect of Cyclist's Mass on Distance He Can Coast (Version 3)

Jim is trying to find out why some children can coast further on their bicycles than others can. He wants to know whether a person's mass influences the distance he or she can coast. To find out, he gathered four of his classmates, Bill, Jane, Terry and Phyllis, who all had the same kind of bicycles, at the top of a hill near the school.

One at a time each started downhill by pushing off with his foot. Jim measured how far each travelled before needing to pedal to keep the bike balanced. Each friend did this three times and then Jim used the school nurse's scale to find their mass and height.

Here is the information Jim collected.

Student		Starting Point	Pedalled at Start	Distance Travelled when Started to Pedal	Type of Bicycle	Mass	Height	Boy or Girl
Bill	1st try	top of hill	no	300 m	10 speed Sekine	35 kg	1.3 m	Boy
	2nd try	top of hill	no	290 m	10 speed Sekine			
	3rd try	top of hill	no	290 m	10 speed Sekine			
Jane	1st try	top of hill	no	320 m	10 speed Sekine	36 kg	1.2 m	Girl
	2nd try	top of hill	no	320 m	10 speed Sekine			
	3rd try	top of hill	no	320 m	10 speed Sekine			
Terry	1st try	top of hill	no	330 m	10 speed Sekine	41 kg	1.5 m	Boy
	2nd try	top of hill	no	331 m	10 speed Sekine			
	3rd try	top of hill	no	331 m	10 speed Sekine			
Phyllis	1st try	top of hill	no	328 m	10 speed Sekine	38 kg	1.1 m	Girl
	2nd try	top of hill	no	327 m	10 speed Sekine			
	3rd try	top of hill	no	328 m	10 speed Sekine			

Directions: Use the above information to fill in this chart so that Jim can answer the question: "Does a person's mass make a difference to the distance he or she can coast on a bicycle?"

Add more rows or columns if you need them.

	Distance Travelled Before Pedalling		
Person's Mass	First Time	Second Time	Third Time
Bill			
Jane			
Phyllis			
Terry			

4. Effect of Soil Type on Growth of Plants (Version 1)

A class is studying how the type of soil affects the amount of growth in plants. They put each kind of soil in a different pot and planted three seeds in each pot. They were careful to keep everything else the same for each of the seedlings. Then they measured the height that each plant grew.

Here is the information they collected.

Type of Soil	Seed	Amount of water every day	Exposure of window pots kept in	Number of days until first sprout appears	Height of seedling in two weeks	Height of seedling in three weeks	Colour of stem
sand	1st	.05 L	east	7 days	4.0 cm	8.0 cm	green
	2nd	.05 L	east	9 days	3.0 cm	9.0 cm	green
	3rd	.05 L	east	5 days	3.5 cm	7.0 cm	green
sand & plant food	1st	.05 L	east	5 days	7.0 cm	11.0 cm	green
	2nd	.05 L	east	6 days	6.5 cm	12.5 cm	green
	3rd	.05 L	east	3 days	6.0 cm	12.0 cm	green
peat moss	1st	.05 L	east	8 days	5.0 cm	10.0 cm	green
	2nd	.05 L	east	7 days	4.0 cm	9.0 cm	green
	3rd	.05 L	east	6 days	4.5 cm	9.0 cm	green
garden soil	1st	.05 L	east	6 days	6.0 cm	12.0 cm	green
	2nd	.05 L	east	5 days	6.5 cm	12.0 cm	green
	3rd	.05 L	east	4 days	7.0 cm	12.5 cm	green

Directions: Their question is: "Which kind of soil helps plants to grow the tallest?" Which of the following charts is the best way to show the information they need to answer their question?

Circle the letter of the correct answer.

(a)

Type of Soil	Number of days until sprout appears: 1st Seed	2nd Seed	3rd Seed
Sand	7 days	9 days	5 days
Sand and Plant Food	5 days	6 days	3 days
Peat Moss	8 days	7 days	6 days
Garden Soil	6 days	5 days	4 days

(b)

Soil Type	Total Amount Seedling Grew in Three Weeks		
	1st Seed	2nd Seed	3rd Seed
Sand & Plant Food	11.0 cm	12.5 cm	12.0 cm
Garden Soil	12.0 cm	12.0 cm	12.5 cm

(c)

Seed	Total Amount Seedlings Grew in Three Weeks
1st	8.0 cm
2nd	7.0 cm
3rd	7.0 cm
1st	11.0 cm
2nd	12.5 cm
3rd	12.0 cm
1st	10.0 cm
2nd	9.0 cm
3rd	9.0 cm
1st	12.0 cm
2nd	12.0 cm
3rd	12.5 cm

Seed	Type of Soil
1st	sand
2nd	sand
3rd	sand
1st	sand and plant food
2nd	sand and plant food
3rd	sand and plant food
1st	peat moss
2nd	peat moss
3rd	peat moss
1st	garden soil
2nd	garden soil
3rd	garden soil

(d)

Type of Soil	Total Amount Seedlings Grew in Three Weeks			Number of days until Sprout Appears		
	1st	2nd	3rd	1st	2nd	3rd
sand	8.0 cm	7.0 cm	7.0 cm	7 days	9 days	5 days
sand and plant food	11.0 cm	12.5 cm	12.0 cm	5 days	6 days	3 days
peat moss	10.0 cm	9.0 cm	9.0 cm	8 days	7 days	6 days
garden soil	12.0 cm	12.0 cm	12.5 cm	6 days	5 days	4 days

(e)

Type of Soil	Total Amount Seedlings Grew in Three Weeks		
	1st	2nd	3rd
sand	8.0 cm	7.0 cm	7.0 cm
sand and plant food	11.0 cm	12.5 cm	12.0 cm
peat moss	10.0 cm	9.0 cm	9.0 cm
garden soil	12.0 cm	12.0 cm	12.5 cm

4. Effect of Soil Type on Growth of Plants (Version 2)

A class is studying how the type of soil affects the amount of growth in plants. They put each kind of soil in a different pot and planted three seeds in each pot. They were careful to keep everything else the same for each of the seedlings. Then they measured the height that each plant grew.

Here is the information they collected.

Type of Soil	Seed	Amount of water every day	Exposure of window pots kept in	Number of days until first sprout appears	Height of seedling in two weeks	Height of seedling in three weeks	Colour of stem
sand	1st	.05 L	east	7 days	4.0 cm	8.0 cm	green
	2nd	.05 L	east	9 days	3.0 cm	9.0 cm	green
	3rd	.05 L	east	5 days	3.5 cm	7.0 cm	green
sand & plant food	1st	.05 L	east	5 days	7.0 cm	11.0 cm	green
	2nd	.05 L	east	6 days	6.5 cm	12.5 cm	green
	3rd	.05 L	east	3 days	6.0 cm	12.0 cm	green
peat moss	1st	.05 L	east	8 days	5.0 cm	10.0 cm	green
	2nd	.05 L	east	7 days	4.0 cm	9.0 cm	green
	3rd	.05 L	east	6 days	4.5 cm	9.0 cm	green
garden soil	1st	.05 L	east	6 days	6.0 cm	12.0 cm	green
	2nd	.05 L	east	5 days	6.5 cm	12.0 cm	green
	3rd	.05 L	east	4 days	7.0 cm	12.5 cm	green

Directions: The class made up this chart to record the information that would help them answer their question: "Which kind of soil helps plants grow the tallest?"

Total Amount Seedlings Grew In 3 Weeks

Type of Soil		1st	2nd	3rd
sand	(m)	(a)	(b)	(c)
sand and plant food	(n)	(d)	(e)	(f)
peat moss	(o)	(g)	(h)	(i)
garden soil	(p)	(j)	(k)	(l)

1. How should the class record the information that the four 1st seeds grew 8.0 cm, 11.0 cm, 10.0 cm and 12.0 cm each in three weeks?

Circle the number of the correct answer.

(i) Put the numbers in spaces (a), (d), (g) and (j).

(ii) Put the numbers in spaces (m), (a), (b) and (c).

(iii) Make up new spaces for the information.

(iv) Leave it out.

2. How should the class record the information that the 1st seeds planted in peat moss sprouted in 8 days?

Circle the number of the correct answer.

(i) Include it in space (g).

(ii) Include it in space (a).

(iii) Make up a new space for the information.

(iv) Leave it out.

3. How should the class record the information that each plant was placed in a window with an eastern exposure?

Circle the number of the correct answer.

(i) Record it in spaces (m), (n), (o) and (p) in the soil type column.

(ii) Record it in each of the spaces (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k) and (l).

(iii) Make up new spaces for the information.

(iv) Leave it out.

4. How should the class record the information that the 3rd seed planted in sand and plant food was 12.0 cm high three weeks after planting?

Circle the number of the correct answer.

(i) In space (b).

(ii) In space (f).

(iii) Make up a new space for the information.

(iv) Leave it out.

4. Effect of Soil Type on Growth of Plants (Version 3)

A class is studying how the type of soil affects the amount of growth in plants. They put each kind of soil in a different pot and planted three seeds in each pot. They were careful to keep everything else the same for each of the seedlings. Then they measured the height that each plant grew.

Here is the information they collected.

Type of Soil	Seed	Amount of water every day	Exposure of window pots kept in	Number of days until first sprout appears	Height of seedling in two weeks	Height of seedling in three weeks	Colour of stem
sand	1st	.05 L	east	7 days	4.0 cm	8.0 cm	green
	2nd	.05 L	east	9 days	3.0 cm	9.0 cm.	green
	3rd	.05 L	east	5 days	3.5 cm	7.0 cm	green
sand & plant food	1st	.05 L	east	5 days	7.0 cm	11.0 cm	green
	2nd	.05 L	east	6 days	6.5 cm	12.5 cm	green
	3rd	.05 L	east	3 days	6.0 cm	12.0 cm	green
peat moss	1st	.05 L	east	8 days	5.0 cm	10.0 cm	green
	2nd	.05 L	east	7 days	4.0 cm	[illegible].0 cm	green
	3rd	.05 L	east	6 days	4.5 cm	[illegible].0 cm	green
garden soil	1st	.05 L	east	6 days	6.0 cm.	12.0 cm	green
	2nd	.05 L	east	5 days	6.5 cm	12.0 cm	green
	3rd	.05 L	east	4 days	7.0 cm	12.5 cm	green

Directions: Use the above information to fill in this chart so that the class can answer their question: "Which kind of soil helps plants to grow the tallest?"

Add more rows or columns if you need them.

Total Amount Seedlings Grew in 3 Weeks

Type of Soil	1st	2nd	3rd
sand			
sand and plant food			
peat moss			
garden soil			

5. Effect of Water Temperature on Germination Time (Version 1)

Paul wants to know whether the temperature of water will affect the time a seed takes to sprout. The class helped Paul plant seeds in soil in pots. They set the pots together in a sunny classroom window and watered them everyday. They kept everything the same for all the seed pots except for three different temperatures of water, cool, warm and hot. They watched them for two weeks.

Here is the information Paul collected.

	Number of seeds in pot	Type of Seed	Amount of water each day	Days until sprout appears	Height of sprout in two weeks	Colour of sprout in two weeks
Used Cool Water						
- 1st plant	1	bean	.05 L	6	4 cm	green
- 2nd plant	1	bean	.05 L	7	3 cm	green
- 3rd plant	1	bean	.05 L	6	5 cm	green
Used Warm Water						
- 1st plant	1	bean	.05 L	5	5 cm	green
- 2nd plant	1	bean	.05 L	5	5 cm	green
- 3rd plant	1	bean	.05 L	6	4 cm	green
Used Hot Water						
- 1st plant	1	bean	.05 L	no sprout	0	---
- 2nd plant	1	bean	.05 L	no sprout	0	---
- 3rd plant	1	bean	.05 L	no sprout	0	---

Directions: The class made charts of the information in their notebooks. Which one do you think is best to help Paul answer his question, "Does the temperature of the water affect the time a seed takes to sprout?"

Circle the letter of the correct answer.

(a)

	Height of Sprout		
	1st plant	2nd plant	3rd plant
Cool Water	4 cm	3 cm	5 cm
Warm Water	5 cm	5 cm	5 cm
Hot Water	0	0	0

(b)

	Sprouting Time		
	1st plant	2nd plant	3rd plant
Cool Water	6 days	7 days	6 days
Warm Water	5 days	5 days	6 days
Hot Water	no sprout	no sprout	no sprout

(c)

	Sprouting Time		
	1st plant	2nd plant	3rd plant
Cool Water	6 days	7 days	6 days
Warm Water	5 days	5 days	6 days

(d)

	Sprouting Time			Height of Sprout		
	1st plant	2nd plant	3rd plant	1st plant	2nd plant	3rd plant
Cool Water	6 days	7 days	6 days	4 cm	3 cm	5 cm
Warm Water	5 days	5 days	6 days	5 cm	5 cm	4 cm
Hot Water	no sprout	no sprout	no sprout	0	0	0

(e)

Temperature of Water	Plant	Sprouting Time	Plant
cool	1st	6 days	1st
cool	2nd	7 days	2nd
cool	3rd	6 days	3rd
warm	1st	5 days	1st
warm	2nd	5 days	2nd
warm	3rd	6 days	3rd
hot	1st	no sprout	1st
hot	2nd	no sprout	2nd
hot	3rd	no sprout	3rd

5. Effect of Water Temperature on Germination Time (Version 2)

Paul wants to know whether the temperature of water will affect the time a seed takes to sprout. The class helped Paul plant seeds in soil in pots. They set the pots together in a sunny classroom window, and watered them everyday. They kept everything the same for all the seed pots except for three different temperatures of water, cool, warm and hot. They watched them for two weeks.

Here is the information Paul collected.

	Number of seeds in pot	Type of Seed	Amount of water each day	Days until sprout appears	Height of sprout in two weeks	Colour of sprout in two weeks
Used Cool Water						
- 1st plant	1	bean	.05 L	6	4 cm	green
- 2nd plant	1	bean	.05 L	7	3 cm	green
- 3rd plant	1	bean	.05 L	6	5 cm	green
Used Warm Water						
- 1st plant	1	bean	.05 L	5	5 cm	green
- 2nd plant	1	bean	.05 L	5	5 cm	green
- 3rd plant	1	bean	.05 L	6	4 cm	green
Used Hot Water						
- 1st plant	1	bean	.05 L	no sprout	0	--
- 2nd plant	1	bean	.05 L	no sprout	0	--
- 3rd plant	1	bean	.05 L	no sprout	0	--

Directions: The class designed the following chart to record the information that would help Paul answer his question: "Does the temperature of the water affect the time a seed takes to sprout?"

Temperature of Water	Sprouting Time 1st Plant	2nd Plant	3rd Plant
Cool Water (j)	(a)	(b)	(c)
Warm Water (k)	(d)	(e)	(f)
Hot Water (l)	(g)	(h)	(i)

1. How should Paul record the information that the sprout appeared in the first pot watered with cool water in six days?

Circle the number of the correct answer.

(i) Put 6 days in space (a).

(ii) Put 6 days in space (e).

(iii) Make up a new space for the information.

(iv) Leave it out.

2. How should Paul record the information that each pot received .05 L of water each day?

Circle the number of the correct answer.

(i) Record it in the spaces (j), (k) and (l).

(ii) Record it in each of the spaces (a), (b), (c), (d), (e), (f), (g), (h) and (i).

(iii) Make up new spaces for the information.

(iv) Leave it out.

3. How should Paul record the information that the third plant watered with cool water was 5 cm high at the end of two weeks?

Circle the number of the correct answer.

(i) Include it in space (c).

(ii) Include it in space (j).

(iii) Make up a new space for the information.

(iv) Leave it out.

4. How should Paul record the information that at the end of two weeks no sprout had appeared in any of the pots watered with hot water?

Circle the number of the correct answer.

(i) Put "no sprout" in spaces (a), (b) and (c).

(ii) Put "no sprout" in spaces (g), (h) and (i).

(iii) Make up new spaces for the information.

(iv) Leave it out.

5. Effect of Water Temperature on Germination Time (Version 3)

Paul wants to know whether the temperature of water will affect the time a seed takes to sprout. The class helped Paul plant seeds in soil in pots. They set the pots together in a sunny classroom window and watered them everyday. They kept everything the same for all the seed pots except for three different temperatures of water, cool, warm and hot. They watched them for two weeks.

Here is the information Paul collected.

	Number of seeds in pot	Type of Seed	Amount of water each day	Days until sprout appears	Height of sprout in two weeks	Colour of sprout in two weeks
Used Cool Water						
- 1st plant	1	bean	.05 L	6	4 cm	green
- 2nd plant	1	bean	.05 L	7	3 cm	green
- 3rd plant	1	bean	.05 L	6	5 cm	green
Used Warm Water						
- 1st plant	1	bean	.05 L	5	5 cm	green
- 2nd plant	1	bean	.05 L	5	5 cm	green
- 3rd plant	1	bean	.05 L	6	4 cm	green
Used Hot Water						
- 1st plant	1	bean	.05 L	no sprout	0	--
- 2nd plant	1	bean	.05 L	no sprout	0	--
- 3rd plant	1	bean	.05 L	no sprout	0	--

Directions: Use the above information to fill in the following chart so that Paul can answer his question: "Does the temperature of the water affect the time a seed takes to sprout?"

Add more rows or columns if you need them.

Temperature of Water	Sprouting Time 1st plant	2nd plant	3rd plant
Cool Water			
Warm Water			
Hot Water			

6. Size and Volume of Marbles
(Version 1)

Ann wanted to find out if the mass of a marble is related to its volume. She collected some small, medium and large marbles of different colours and materials. She made sure she had a marble of each material in each size. She dropped them one by one into water in a glass cylinder. The cylinder had markings on the side so she could tell how many mL the water rose when she added a marble.

Here is the information Ann collected.

Level of water in cylinder when no marble is in it	Colour of Marble	Size of Marble	Material marble made of	Level of water in cylinder after marble is added	Volume of Marble
20 mL	blue	1st small one	glass	22.5 mL	2.5 mL
20 mL	orange	1st medium one	stone	23.0 mL	3.0 mL
20 mL	red	2nd small one	stone	22.0 mL	2.0 mL
20 mL	yellow	1st large one	plastic	25.0 mL	5.0 mL
20 mL	green	2nd medium one	plastic	23.5 mL	3.5 mL
20 mL	yellow	3rd medium one	glass	23.0 mL	3.0 mL
20 mL	green	3rd small one	plastic	21.75 mL	1.75 mL
20 mL	red	2nd large one	glass	24.5 mL	4.5 mL
20 mL	blue	3rd large one	stone	25.0 mL	5.0 mL

Directions: She tried different ways to organize the information into a chart that would help her to answer her question, "Is the mass of a marble related to its volume?"

Circle the letter of the correct one.

(a)

	Material marble made of		
Size of Marble	1st marble	2nd marble	3rd marble
small	glass	stone	plastic
medium	stone	plastic	glass
large	plastic	glass	stone

(b)

	Volume of Marble	
Size of Marble	1st marble	3rd marble
small	2.5 mL	1.75 mL
medium	3.0 mL	3.0 mL
large	5.0 mL	5.0 mL

(c)

	Volume of Marble			Material marble made of		
Size of Marble	1st marble	2nd marble	3rd marble	1st marble	2nd marble	3rd marble
small	2.5 mL	2.0 mL	1.75 mL	glass	stone	plastic
medium	3.0 mL	3.5 mL	3.0 mL	stone	plastic	glass
large	5.0 mL	4.5 mL	5.0 mL	plastic	glass	stone

(d)

	Volume of Marble		
Size of Marble	1st marble	2nd marble	3rd marble
small	2.5 mL	2.0 mL	1.75 mL
medium	3.0 mL	3.5 mL	3.0 mL
large	5.0 mL	4.5 mL	5.0 mL

(e)

	Size of Marble		
1st marble	small	medium	large
2nd marble	small	medium	large
3rd marble	small	medium	large

	Volume of Marble		
1st marble	2.5 mL	2.0 mL	1.75 mL
2nd marble	3.0 mL	3.5 mL	3.0 mL
3rd marble	5.0 mL	4.5 mL	5.0 mL

6. Size and Volume of Marbles
(Version 2)

Ann wanted to find out if the mass of a marble is related to its volume. She collected some small, medium and large marbles of different colours and materials. She made sure she had a marble of each material in each size. She dropped them one by one into water in a glass cylinder. The cylinder had markings on the side so she could tell how many mL the water rose when she added a marble.

Here is the information Ann collected.

Level of water in cylinder when no marble is in it	Colour of Marble	Size of Marble	Material marble made of	Level of water in cylinder after marble is added	Volume of Marble
20 mL	blue	1st small one	glass	22.5 mL	2.5 mL
20 mL	orange	1st medium one	stone	23.0 mL	3.0 mL
20 mL	red	2nd small one	stone	22.0 mL	2.0 mL
20 mL	yellow	1st large one	plastic	25.0 mL	5.0 mL
20 mL	green	2nd medium one	plastic	23.5 mL	3.5 mL
20 mL	yellow	3rd medium one	glass	23.0 mL	3.0 mL
20 mL	green	3rd small one	plastic	21.75 mL	1.75 mL
20 mL	red	2nd large one	glass	24.5 mL	4.5 mL
20 mL	blue	3rd large one	stone	25.0 mL	5.0 mL

Directions: Ann designed this chart to record the information that would help her answer her question: "Is there a relationship between the volume of a marble and its mass?"

Size of Marble	Volume of Marble: 1st marble	2nd marble	3rd marble
small (j)	(a)	(b)	(c)
medium (k)	(d)	(e)	(f)
large (l)	(g)	(h)	(i)

1. How should Ann record the information that the first large marble has a volume of 5 mL?

Circle the number of the correct answer.

(i) Put "5 mL" in space (g).

(ii) Put "5 mL" in space (f).

(iii) Make up a new space for the information.

(iv) Leave it out.

2. How should Ann record the information that the water in the cylinder stood at 21.75 mL after she added the third small marble?

Circle the number of the correct answer.

(i) Include it in space (c).

(ii) Include it in space (j).

(iii) Make up a new space for the information.

(iv) Leave it out.

3. How should Ann record the information about the material from which each marble is made?

Circle the number of the correct answer.

(i) Include it in the spaces (a), (b), (c), (d), (e), (f), (g), (h) and (i).

(ii) Include it in the spaces (j), (k) and (l).

(iii) Make up new spaces for the information.

(iv) Leave it out.

4. How should Ann record the information that the volumes of the medium-sized marbles were 3.0 mL, 3.5 mL and 3.0 mL?

Circle the number of the correct answer.

(i) Put these numbers in spaces (d), (e) and (f).

(ii) Put these numbers in spaces (g), (h) and (i).

(iii) Make up new spaces for the information.

(iv) Leave it out.

6. Size and Volume of Marbles
(Version 3)

Ann wanted to find out if the mass of a marble is related to its volume. She collected some small, medium and large marbles of different colours and materials. She made sure she had a marble of each material in each size. She dropped them one by one into water in a glass cylinder. The cylinder had markings on the side so she could tell how many mL the water rose when she added a marble.

Here is the information Ann collected.

Level of water in cylinder when no marble is in it	Colour of Marble	Size of Marble	Material marble made of	Level of water in cylinder after marble is added	Volume of Marble
20 mL	blue	1st small one	glass	22.5 mL	2.5 mL
20 mL	orange	1st medium one	stone	23.0 mL	3.0 mL
20 mL	red	2nd small one	stone	22.0 mL	2.0 mL
20 mL	yellow	1st large one	plastic	25.0 mL	5.0 mL
20 mL	green	2nd medium one	plastic	23.5 mL	3.5 mL
20 mL	yellow	3rd medium one	glass	23.0 mL	3.0 mL
20 mL	green	3rd small one	plastic	21.75 mL	1.75 mL
20 mL	red	2nd large one	glass	24.5 mL	4.5 mL
20 mL	blue	3rd large one	stone	25.0 mL	5.0 mL

Directions: Use the above information to fill in this chart so that Ann can answer her question: "Is there a relationship between the volume of a marble and its mass?"

Add more rows or columns if you need them.

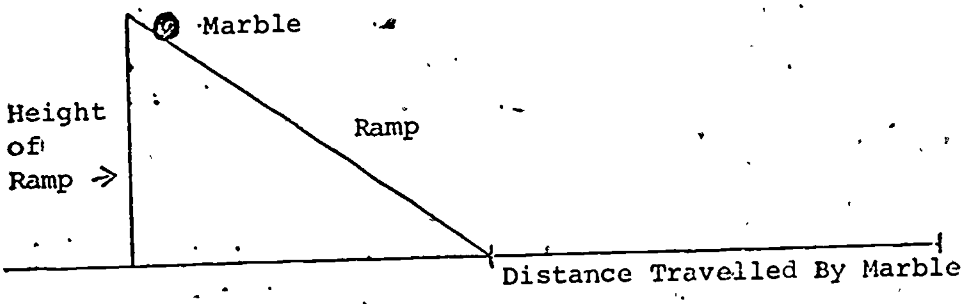
	Volume of Marble		
Size of Marble	1st marble	2nd marble	3rd marble
small			
medium			
large			

E. OBSERVING RELATIONSHIPS IN DATA - Junior Level

Answer Sheet

Items	Levels 1	2	3	4
1. Ramp	a	b	d	c
2. Moose & Wolves	c	d	b	a
3. Magnets	b	a	c	d
4. Plants & Sunlight	d	c	a	b
5. Plants & Water	d	c	b	a
6. Plants & Fertilizer	c	b	a	d
7. Pendulum	b	d	c	a
8. Shadows	a	c	d	b
9. Animal Coverings - fur	b	a	d	c
10. Solutions	b	d	c	a

1. Ramp



Richard did an experiment in which marbles of different mass rolled down a ramp. He wanted to find out if the distance travelled by each marble is influenced by the mass of the marble. These were his results:

Distance Travelled by Marble

Trial	1 g marble	2 g marble	3 g marble
1st	12	17	24
2nd	14	16	22
3rd	11	19	23
4th	15	14	18
5th	9	15	25

Directions: What would be the best way to find out if there is a relationship between the mass of a marble and the distance it travels down the ramp?

Circle the letter of the best answer.

(a) Study the information for the 1st, 2nd and 3rd trials of the 2 g marble. See what happens to the distance the marble travels on these rolls.

(b) Find the longest and shortest distance travelled. See if the marble's mass is bigger for the longest distance than it is for the shortest distance.

(c) Look at all the information. See if the distance travelled is always longer as the marble's mass gets bigger.

(d) Compare the distance the marble travelled on the middle trial for each mass. See if the distance increases as the mass of the marble increases.

2. Moose and Wolves

Frank thinks that wolves may kill moose. He got some information about the changing numbers of moose and wolves in Algonquin Park. He wanted to find out if the number of wolves living in the Park influenced the number of moose living in the Park.

Here is the information he received:

Year	Number of Wolves	Number of Moose
1967	78	53
1968	100	44
1969	124	33
1970	148	20
1971	151	21
1972	124	30
1973	98	43
1974	73	54
1975	105	42
1976	135	36
1977	161	28
1978	204	18

Directions: What would be the best way to find out if there is a relationship between the number of wolves and the number of moose in the Park?

Circle the letter of the best answer.

(a) Look at all the information. See if the number of moose always gets smaller if the number of wolves gets larger.

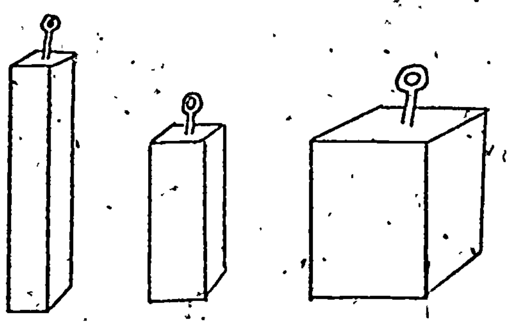
(b) Look at the numbers for the first and last years. If there are more wolves in 1978 than there were in 1968, see if there are fewer moose in 1978 than there were in 1968.

(c) Look at 1969 and 1972 when the number of wolves was the same. See what happened to the number of moose in these years.

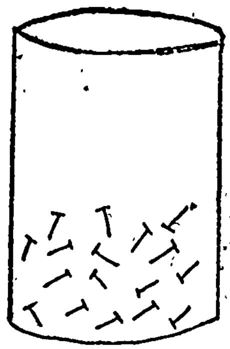
(d) Find the years when there was the most and the least wolves. See if there are fewer moose when there are the most wolves and the most moose when there are fewer wolves.

3. Magnets

Bob has done an experiment in which magnets of different sizes were lowered into a can of pins. He wanted to see if the larger magnets attracted more pins than the smaller ones.



Various Sized Magnets



Can Half Full of Push Pins

These were his results:

Size of Magnet		Number of Pins Picked Up
Smallest	1st trial	66
	2nd trial	55
	3rd trial	70
Medium	1st trial	75
	2nd trial	75
	3rd trial	79
Largest	1st trial	90
	2nd trial	89
	3rd trial	96

Directions: What would be the best way to find out if there is a relationship between the size of the magnet and the power of the magnet?

Circle the letter of the best answer.

(a) Find the largest and smallest number of pins picked up. See if the magnet size is greater for the largest number of pins than it is for the smallest number.

(b) Study the data for the 1st, 2nd and 3rd trials of the medium sized magnet. See how many pins the magnet picked up on each of these trials.

(c) Compare the number of pins picked up on the middle trial for each sized magnet. See if the number of pins picked up increases as the size of the magnet increases.

(d) Look at all the data. See if the number of pins the magnet picked up is always greater as the magnet size gets bigger.

4. Plants and Sunlight

John set up an experiment to see if there was a relationship between the growth of plants and the amount of sunlight they received. He used nine plants. All were treated the same except that three of them received 6 hours of sunlight per day, three received 9 hours and three received 12 hours. At the end of the month he measured the height of each plant and recorded his findings.

Here are the results:

Amount of Sunlight/Day	Height of Plants After One Month Plant 1	Plant 2	Plant 3
6 hours	15 cm	13 cm	18 cm
9 hours	14 cm	22 cm	20 cm
12 hours	20 cm	26 cm	21 cm

Directions: What would be the best way for John to decide if there is a relationship between the growth of plants and the amount of sunlight they receive?

Circle the letter of the best answer.

(a) Examine the growth recorded for the last plant in each group. See if the height of the plants increase as the hours of sunlight increases.

(b) Study all of the results to see whether a plant always showed more growth when it received more sunlight.

(c) Compare the plant that grew the most and the plant that grew the least. See if the tallest plant received the most sunlight possible and the shortest received the least sunlight possible.

(d) Look at the three plants that received 6 hours of sunlight per day. See how tall each of them became.

5. Plants and Water

A class wanted to know if there was any connection between the amount of water a plant is given and the height to which it will grow. They set up an experiment using nine plants. To three of the plants they gave 100 mL of water per day, to another three, 150 mL of water per day and the last three, 200 mL of water per day. At the end of a week they measured the height of each plant and recorded their findings as follows:

Height of Plants After 1 Week

	100 mL Daily	150 mL Daily	200 mL Daily
Plant 1	5 cm	5 cm	7 cm
Plant 2	3 cm	8 cm	15 cm
Plant 3	4 cm	10 cm	9 cm

Directions: How could the class best decide whether there is a relationship between the amount of water a plant is given and the height to which it will grow?

Circle the letter of the best answer.

(a) Study all of the results. See if the plants were always taller when they received more water.

(b) Compare the growth of the first plant in each water group. See if there is a connection between the amount of water and the height to which the plants grew.

(c) Find the tallest plant and the shortest plant. See if the tallest plant was given the most water and the shortest plant the least water.

(d) Look at the results with the plants that got the most water every day. See what happened to each of them and how high they grew.

6. Plants and Fertilizer

A class did an experiment to see if there was any connection between the growth of a plant and the amount of fertilizer it was given. In the experiment they used 12 plants. To three of them they gave no fertilizer at all, to the next three they gave 2 g of fertilizer, to another three they gave 4 g of fertilizer and the last three they gave 6 g of fertilizer.

Following are the results they observed:

Height of Plants In Two Weeks

	0 g Fertilizer	2 g Fertilizer	4 g Fertilizer	6 g Fertilizer
Plant 1	2 cm	3 cm	5 cm	9 cm
Plant 2	1 cm	4 cm	4 cm	6 cm
Plant 3	2 cm	2 cm	7 cm	5 cm

Directions: What should the class do to decide if there is a relationship between plant growth and the amount of fertilizer used?

Circle the letter of the best answer.

(a) Compare the growth of one plant getting each amount of fertilizer. See if there is a connection between that amount and how much they grew.

(b) Compare the plant with the greatest amount of growth with that showing the least growth. See if the tallest plant was given the most fertilizer and the shortest plant the least fertilizer.

(c) Look at the results for the three plants receiving the most fertilizer. See how much they grew.

(d) Examine all of the information. See if the plants always grew more when they were given more fertilizer.

7. Pendulum

Bob, Jane and Mary did an experiment to see if the length of the arm of a pendulum is related to how fast it swings. They made pendulums of four different lengths. Then they took turns swinging each pendulum. They used a watch to find out how long each pendulum took to complete 10 swings. They put all their results into one chart as follows:

	Time To Complete 10 Swings		
Length of Pendulum Arm	Bob	Jane	Mary
10 cm	4 s	3 s	5 s
15 cm	10 s	9 s	5 s
20 cm	11 s	11 s	11 s
25 cm	16 s	14 s	18 s

Directions: What should they do to decide if there is a connection between the pendulum length and the time it takes to swing?

Circle the letter of the best answer.

(a) Study all of the data. See if the time always increases as the length of the pendulum arm increases.

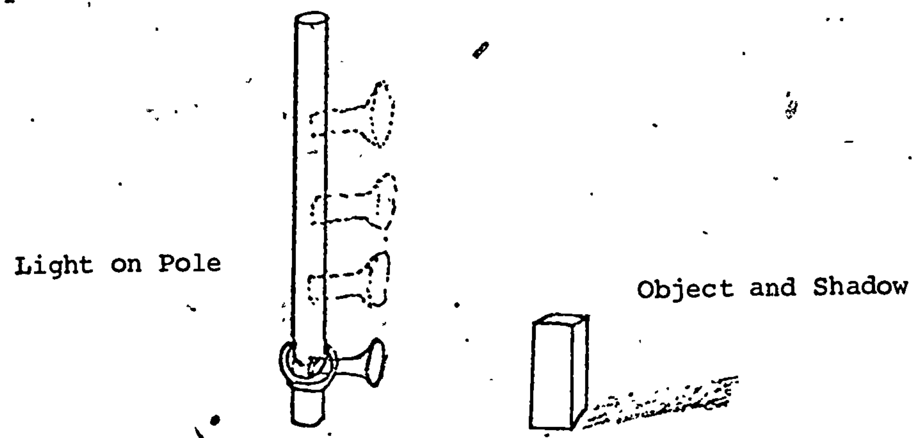
(b) Study the times noted by Bob, Jane and Mary for the shortest pendulum. See how long it took to make 10 swings when each of them tried.

(c) Compare all the times recorded by Mary and see if the time increases as the length of the pendulum arm increases.

(d) Look at the longest time taken and the shortest time taken. See if the longest time was taken by the longest pendulum arm and the shortest time by the shortest pendulum arm.

8. Shadows

Bob, Alice and Ted did an experiment to study the length of shadows. Each attached a light to a pole. The light could be attached in different positions up and down the pole. In turn each placed an object the same distance in front of the pole. They measured the length of the shadow for each different position of the light that they tried.



Here are their results on one chart:

Position of Light	Length of Shadow Bob's Object	Alice's Object	Ted's Object
Directly behind object	6 cm	8 cm	10 cm
3 cm above object	5 cm	6 cm	8 cm
6 cm above object	4 cm	5 cm	7 cm
9 cm above object	2 cm	4 cm	5 cm

Directions: What would be the best way for them to decide if there is a connection between the height of the light and the length of the shadow?

Circle the letter of the best answer.

(a) Study the length of the 3 shadows when the light was highest. See how long each of them is.

(b) Study all the results. See if the shadow always gets shorter when the light is raised to a higher position.

(c) Find the longest and the shortest shadow. See if the light was at the lowest position for the longest shadow and the highest position for the shortest shadow.

(d) Compare the shadow lengths of Bob's object. See if the shadow gets shorter each time the light is raised.

9. Animal Coverings - Fur

Jeff had noticed that on an animal some fur is long and some is short. He wondered if the length of fur depended on the part of the animal's body it was found on.

He collected the following information:

	Length of Fur					
Part of Body	Wolf	Buffalo	Bear	Badger	Fox	Groundhog
Neck	long	long	long	long	long	long
Stomach	short	long	long	short	short	short
Back	short	short	short	short	short	short

Directions: What would be the best way to find out if there is a relationship between the length of fur and the part of the body on which it is found?

Circle the letter of the best answer.

(a) Pick the biggest and smallest animals. See if they have long and short fur on the same parts of their bodies.

(b) Look at the information about one of the animals. See where the fur is long and short.

(c) Look at all the information. See if long fur and short fur are always on the same part of the body of all the animals.

(d) Look at all the information about one part of the body. See if the same length of fur is on this part of all the animals.

10. Solutions

Dave put equal amounts of water in three different jars. The water in each jar was a different temperature. He added salt, 5 mL at a time, to one of the jars. He stirred the solution and kept adding salt until no more would dissolve. Then he did the same with each of the other jars. He counted the number of 5 mL portions of salt that dissolved in each jar. He repeated the whole experiment 3 times.

Here are his results:

Temperature of Water	Amount of Salt Dissolved in 5 mL Portions		
	Trial 1	Trial 2	Trial 3
Cool	8	7	6
Warm	12	13	12
Hot	21	19	20

Directions: What would be the best way for him to decide if there is a connection between the temperature of the water and the amount of salt that could be dissolved in it?

Circle the letter of the best answer.

(a) Look at all the information. See if more salt always dissolved as the temperature of the water increased.

(b) Study the amount of salt that dissolved in the hot test water. See how much dissolved each time.

(c) Look at the information about the last trial. See if more salt was dissolved as the temperature of the water increased.

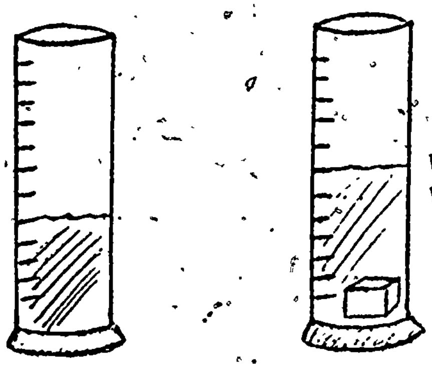
(d) Find the least and the most salt that dissolved. See if the water temperature was different for the two amounts.

F. DRAWING CONCLUSIONS - Junior Level

Answer Sheet

	Levels 0	1	2	3
1. Volume and Size	c	b or d	e	a
2. Plant Growth - Water and Fertilizer	b or e	c	d	a
3. Electromagnets	a or e	d	c	b
4. Pendulum	c or d	a or e	f	b
5. Growth of Fish	a or g	c or e	b or d	f
6. Growth of Plants - Soil and Sun	e or g	c or f	a or b	d
7. Growth of Plants - Blue Liquid & Green Powder	b or d	g or f	a or e	c
8. Sound	a or e	b or d	c	f
9. Shadows	b or e	f or g	c or a	d
10. Animal Coverings -- Fur	b or f	a or d	e or g	c

1. Volume and Size



First, John partially filled with water a narrow graduated cylinder. Then he took three objects made of different substances and placed each, in turn, in the water. For each object he carefully measured the number of cm the water level rose when it was placed in the water.

Here are the results he obtained:

Size of Object	Mass of Object	Amount Water Level Rose
Object 1 (smallest)	10 g	4 cm
Object 2 (medium)	15 g	8 cm
Object 3 (largest)	5 g	12 cm

Here are some statements about the results of the experiment.

1. The volume of the object was affected by its mass.
2. The volume of the object was affected by its size.
3. As the size of the object increased, its volume increased.
4. The volume of the object was unrelated to its mass.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 3 and statement 4.

(b) Statement 2 only.

(c) Statement 1 only.

(d) Statement 4 only.

(e) Statement 3 only.

2. Plant Growth

A group of students did an experiment with plants. They planted radish seeds in 6 pots. They added fertilizer to pots 1, 2 and 3, but gave no fertilizer to pots 4, 5 and 6. Pots 1 and 4 got .01 L of water daily, pots 2 and 5 got .03 L of water daily and pots 3 and 6 got .05 L of water daily. At the end of 3 weeks they measured the height of the seedling in each pot.

Here are the results:

Amount of Water Daily	Height of Seedlings in 3 Weeks	
	Fertilizer	No Fertilizer
.01 L	Pot 1 - 16 cm	Pot 4 - 10 cm
.03 L	Pot 2 - 17 cm	Pot 5 - 11 cm
.05 L	Pot 3 - 18 cm	Pot 6 - 12 cm

Here are some statements about the results:

1. Adding fertilizer increased the growth of the plants
2. Adding fertilizer to the plants made a difference to how much they grew.
3. As the amount of water given to the unfertilized plants increased the growth of the plants decreased.
4. Increasing the amount of water given daily increased the growth of the plants.

Directions: Which statement or combination of statements best describes the results of the experiment.

Circle the letter of the best answer.

(a) Statement 1 and statement 4 together.

(b) Statement 3 only.

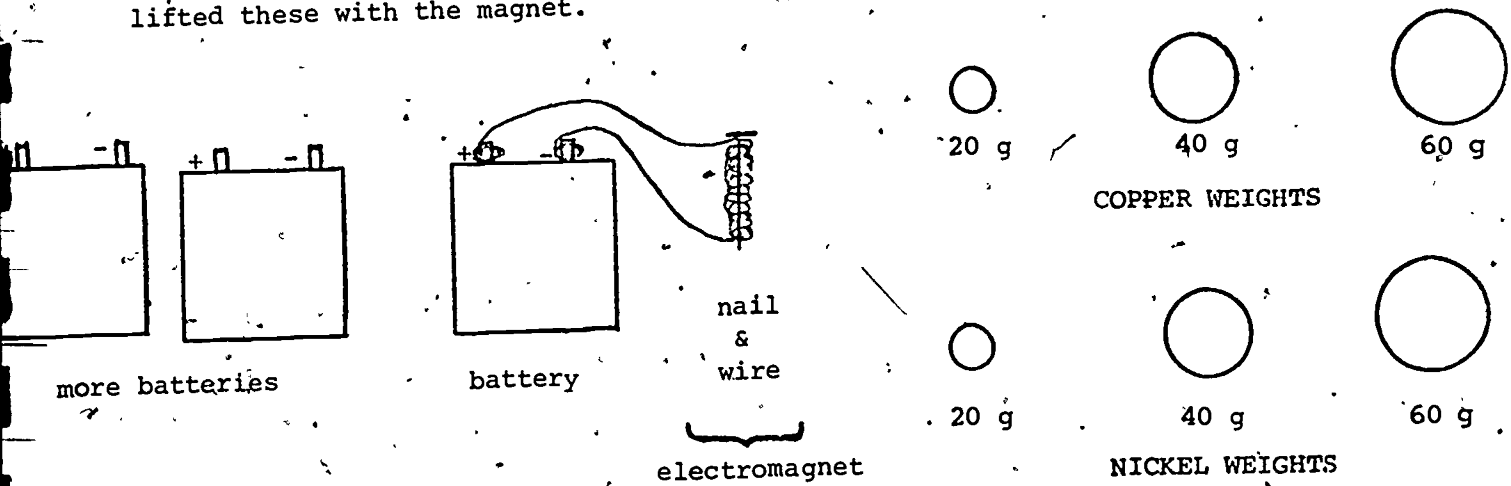
(c) Statement 2 only.

(d) Statement 1 only.

(e) Statement 2 and statement 3 together.

3. Electromagnets

Margaret's teacher made an electromagnet by carefully wrapping a nail with copper wire and attaching the end of the wire to a battery. She had more batteries that she could also attach to increase the power of the magnet. She had a set of weights, some made of copper and some made of nickel. She lifted these with the magnet.



Here are the results she got:

Check mark indicates weight could be lifted.

Number of Batteries in Magnet	Copper 20 g	Copper 40 g	Copper 60 g	Nickel 20 g	Nickel 40 g	Nickel 60 g
1	✓					
2	✓	✓		✓		
3	✓	✓	✓	✓	✓	

Here are some statements about the results:

1. The electromagnet could lift a greater mass of copper than of nickel.
2. As the number of batteries in the magnet was increased, the mass it could lift also increased.
3. When the mass of the copper weights was increased, there was an increase in the mass of the nickel weights.
4. The number of batteries in the magnet made a difference to the mass that could be lifted.

Directions: Which statement or combination of statements best describes the results of her experiment?

Circle the letter of the best answer.

(a) Statement 3 and statement 4 together.

(b) Statement 1 and statement 2 together.

(c) Statement 2 only.

(d) Statement 4 only.

(e) Statement 3 only.

4. Pendulum

A group of students did an experiment with pendulums. They used a string fastened to the edge of a table for the arm of the pendulum, and tied a weight at the other end of it to be the bob. They measured the period of their pendulum (the period is the time the arm takes to make a complete swing). They repeated their measurements with different arm lengths and different bob masses.

Here are their results:

	Time in seconds of 10 swings		
Mass of bob	10 cm arm	20 cm arm	30 cm arm
5 g	5	10	15
10 g	6	10	14
15 g	5	9	15

Here are some statements about the results:

1. As the mass of the bob increased, the length of the arm also increased.
2. Changing the mass of the bob did not affect the period of the pendulum.
3. Increasing the length of the arm increased the period of the pendulum.
4. As the length of the arm was changed, the period of the pendulum also changed.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 2 only.

(b) Statement 2 and statement 3 together.

(c) Statement 1 only.

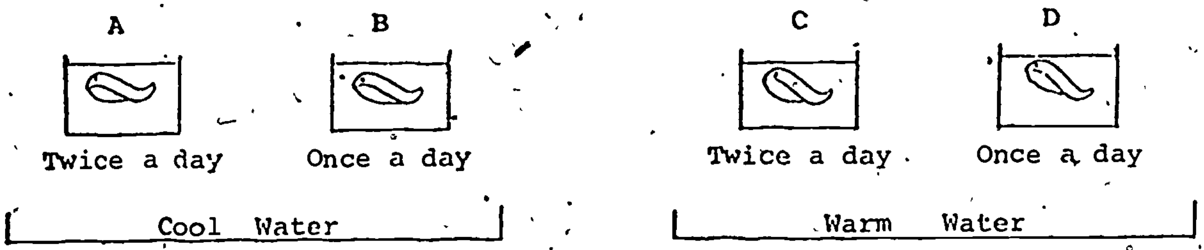
(d) Statement 1 and statement 2 together

(e) Statement 4 only.

(f) Statement 3 only.

5. Growth of Fish

The grade 6 science class did a study with goldfish. They put one of 4 identical fish in each tank. Fish A and B were put in cool water. Fish C and D were put in warm water. Fish A and C were fed twice a day for 20 days while the other 2 were only fed once a day. The gain in mass of the fish between day 1 and day 20 was recorded.



Here are the results:

	Increase in Mass	
Temperature of Water	Fed Once a Day	Fed Twice a Day
Cool	1 g	2 g
Warm	.5 g	1 g

Here are some statements about the results.

1. When the temperature of the water was decreased, the increase in mass was greater.
2. Changing the amount of food given daily made a difference to the increase in mass of the fish.
3. The quantity of food fed to the fish was decreased and over a period of time it was observed that the growth of the fish doubled.
4. When the amount of food the fish received was increased, the increase in mass was greater.
5. The temperature of the water in which the fish were kept affected the growth of the goldfish.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 3 and statement 5 together.
(b) Statement 1 only.
(c) Statement 2 only.
(d) Statement 4 only.
(e) Statement 5 only.
(f) Statement 1 and statement 4 together.
(g) Statement 3 only.

6. Growth of Plants - Soil and Sunlight

A group of students planted some bean seeds in pots and watched them grow. Pots 1 and 2 were filled with sand, pots 3 and 4 with garden loam. The students put pots 1 and 3 in a sunny south window and pots 2 and 4 in a north window that got no direct sun. All plants got the same amount of water daily.

Here are their results:

Kind of Soil	Height of Plants in 3 Weeks Sun	No Sun
Sand	Pot 1 - 5 cm	Pot 2 - 4 cm
Loam	Pot 3 - 9 cm	Pot 4 - 8 cm

Here are some statements about the results:

1. The window in which they were placed made a difference to the growth of the plants.
2. The kind of soil in which they were planted made a difference to the growth of the plants.
3. The plants grew better with direct sunlight than without it.
4. The experiment showed that plants do just as well without direct sunlight.
5. The plants grew better in loam than in sand.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 3 only.

(b) Statement 5 only.

(c) Statement 2 only.

(d) Statement 3 and statement 5 together.

(e) Statement 4 and statement 5 together.

(f) Statement 1 only.

(g) Statement 4 only.

7. Growth of Plants -
blue liquid & green powder

A group of students were given:

- 9 bean seeds
- a bottle of blue liquid
- a box of green powder.

They planted the seeds in separate pots. Each pot contained the same kind of soil. Each pot received the same amount of sunlight and water everyday. Once a week each seed received some of the liquid and some of the powder. After 4 weeks the students measured the height of the plants.

Here are the results:

	Height of Plants		
Amount of blue liquid	50 mg. green powder	100 mg green powder	150 mg green powder
500 mL	4 cm	8 cm	16 cm
1 000 mL	8 cm	16 cm	32 cm
1 500 mL	16 cm	32 cm	64 cm

Here are some statements about the results of the experiment.

1. As the amount of blue liquid the plants received was increased, the height of the plants increased.
2. The blue liquid had an effect on the growth of the plants.
3. As the amount of green powder the plants received was increased, the height of the plants increased.
4. The growth of the plants was affected by the green powder.
5. The experiment showed that increasing the height of the plants decreased the amount of blue liquid they needed.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 3 only.

(b) Statement 5 only.

(c) Statement 1 and statement 3 together.

(d) Statement 4 and statement 5 together.

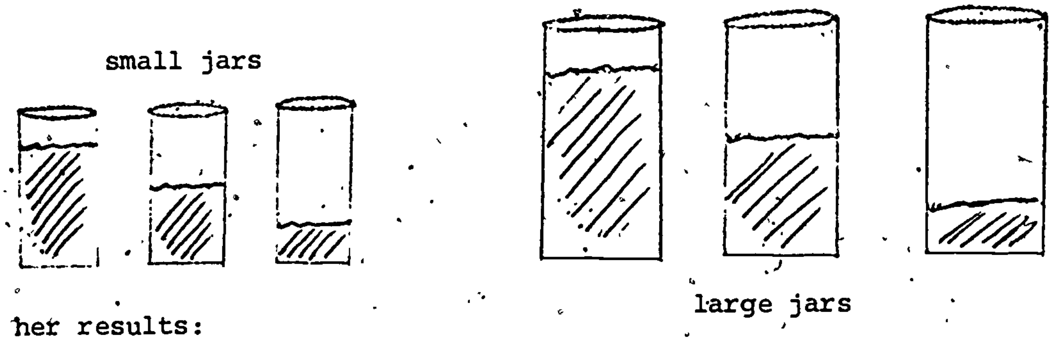
(e) Statement 1 only.

(f) Statement 4 only.

(g) Statement 2 only.

8. Sound

Barb found three small jars the same size. She filled one of them 3/4 full of water, one 1/2 full and the other 1/4 full. She tapped each jar with a pencil and listened to the sound. Then she did the experiment again with three large jars.



Here are her results:

Amount of Water	Pitch of Sound: Small Jars	Large Jars
3/4 full	low	low
1/2 full	medium	medium
1/4 full	high	high

Here are some statements about her results.

1. The size of the jar made no difference to the result.

2. The amount of water in the jar made a difference to the sound.

3. The amount of water in the jar did not make a difference to the sound.

4. Increasing the amount of water in the jar decreased the pitch of the sound.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 3 only.

(b) Statement 1 only.

(c) Statement 4 only.

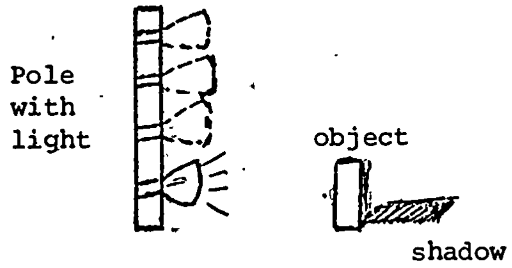
(d) Statement 2 only.

(e) Statement 1 and statement 3 together.

(f) Statement 1 and statement 4 together.

9. Shadows

Bob, Alice and Ted wanted to study shadows. They attached a light to a pole. The light could be attached in different positions up and down the pole. Then in turn each placed an object the same distance in front of the pole. Bob used a block 3 cm high. Alice used a stick 4 cm long and Ted used a stick 5 cm long. They each measured the length of the shadow for each different position of the light that they tried.



Here are their results.

Position of Light	Length of Shadow: Bob's Object (3 cm)	Alice's Object (4 cm)	Ted's Object (5 cm)
Directly behind object	6 cm	8 cm	10 cm
3 cm above object	5 cm	6 cm	8 cm
6 cm above object	4 cm	5 cm	7 cm
9 cm above object	2 cm	4 cm	5 cm

Here are some statements about the results.

1. The size of the object made a difference to the length of the shadow.
2. As the size of the object was increased the length of the shadow increased.
3. When the height of the light was increased the length of the shadow increased.
4. The height of the light had an effect on the length of the shadow.
5. As the height of the light increased the length of the shadow decreased.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 5 only.
(b) Statement 3 only.
(c) Statement 2 only.
(d) Statement 2 and statement 5 together.
(e) Statement 3 and statement 1 together.
(f) Statement 1 only.
(g) Statement 4 only.

10. Animal Coverings - fur

Jeff had noticed that some animal fur is long and some is short. He collected the following information:

Length of Fur

Part of Body	Wolf	Buffalo	Bear	Badger	Fox	Groundhog
Neck	long	long	long	long	long	long
Stomach	short	long	long	short	short	short
Back	short	short	short	short	short	short

Here are some statements about his findings.

1. Different lengths of fur were located on different parts of an animal's body.

2. All animals had long fur on the same parts of their bodies.

3. The wolf, badger, fox and groundhog had long or short fur on the same parts of their bodies but the buffalo and bear were different.

4. Some animals had different lengths of fur on a particular part of their bodies than other animals did.

5. Long fur was most often found on the neck and short fur was most often found on the stomachs and backs of the animals' bodies.

Directions: Which statement or combination of statements best describes the results of his study?

Circle the letter of the best answer.

(a) Statement 4 only.

(b) Statement 2 only.

(c) Statement 3 and statement 5 together.

(d) Statement 1 only.

(e) Statement 5 only.

(f) Statement 2 and statement 4 together.

(g) Statement 3 only.

G. GENERALIZING/PREDICTING - Junior Level A2

Answer Sheet

	1	2	3	4
1. Pendulum	longer than	longer than	shorten arm.	shorten pendulum
2. Pitch & Sound	become lower	on my right	lower	5
3. Shadows	get shorter	changes length	longer	longer than
4. Bicycles	less than 180 cm	more than 220 cm	b	faster
5. Water Currents	slower	b	a	less help
6. Plants (Fertilizer)	a	a	less than	bigger than
7. Plants (Water)	less than 10 cm	more than 10 cm	rains a lot	taller than
8. Plants (Sunlight)	more than 18 cm	less than 6 hours	open sunny area	much taller than
9. Volume & Size	more than 6 cm	smaller than	stone bigger than egg	10 cm
10. Unicycles	Jack	different points	same rate	Jack

Note: Students must choose the correct option on all 4 questions to score correct on an item.

1. Pendulum

Johnny did some experiments to find out what makes pendulums go faster or slower. He tied strings of different lengths to a nail on the edge of a table. He attached different weights to the strings. He also tried some other things but only the length of the arm (the weighted string) affected the period (the length of time taken to make one complete swing) of the pendulum.

He concluded that as the length of the arm was increased, the period of the pendulum also increased.

Directions: From what he had learned, here are some things Johnny might say.

Circle the words that make each statement true.

1. Clocks use pendulums to keep time. If I move the bob down on the clock pendulum and make the arm longer, the period will be (longer than, shorter than, the same as) it was.

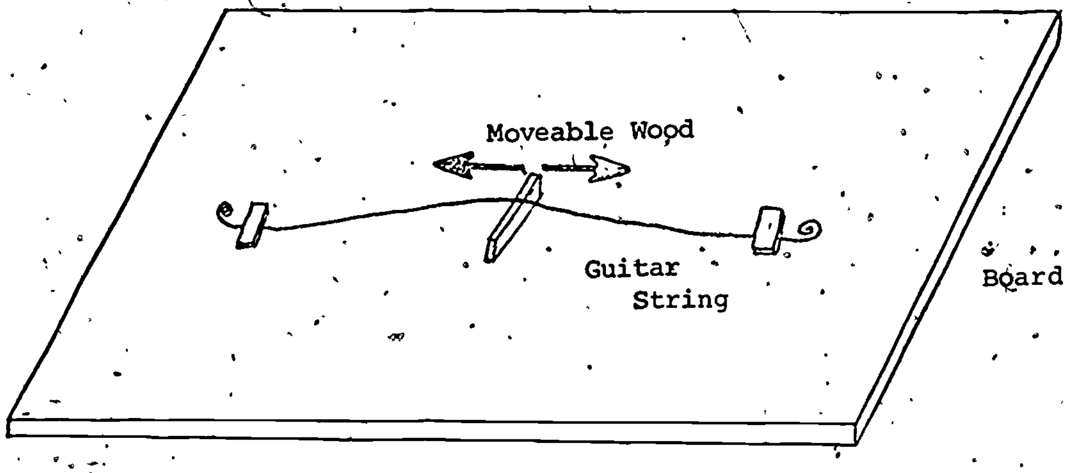
2. If I hung a very long string with a weight on it from a windowsill on the second storey, the period would be (longer than, shorter than, the same as) the period of a grandfather clock.

3. To make a weighted string swing faster I should (lengthen the arm, shorten the arm, leave it the same length).

4. No matter how long the period really is, the second hand of a grandfather clock moves once each time the pendulum swings and the minute hand moves ahead one minute for every 60 swings. If my clock is losing time, that is the minute hand takes longer than 1 minute to move ahead one minute, I would (lengthen the pendulum, shorten the pendulum, leave it the same length).

2. Pitch & Sound

Paul wanted to know how a single guitar string could make different sounds. He fastened a guitar string to a board by nailing a strip of wood across each end. He had another strip of wood which he could place under the string. By moving this strip of wood he could change the length of the string which vibrated when plucked.



Paul concluded that as the piece of string which could vibrate got shorter the sound produced got higher.

Directions: From what he had learned, here are some things Paul might say.

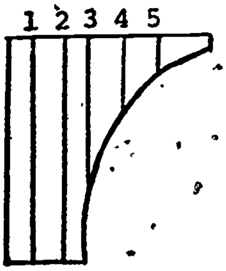
Circle the word or words that make each statement true.

1. If I change the length of a vibrating string from 15 cm to 20 cm the sound produced will (become higher, become lower, stay the same).

2. In a piano a small hammer strikes a wire. As the wire vibrates it produces the sound. If I am sitting at the piano the shorter wires must be (on my left, in front of me, on my right).

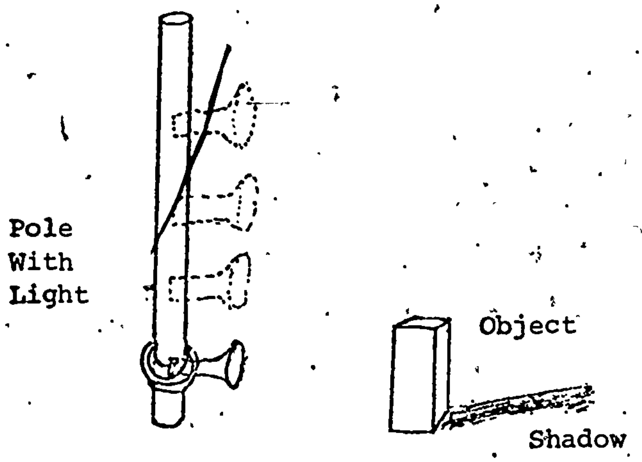
3. The long, thin piece of a guitar is called the neck. If I pluck a string on a guitar the farther out on the neck I put the fingers of my other hand, the sound produced will be (higher, lower, no different).

4. A harp is a stringed instrument. It makes sounds when the strings are plucked. Below is a diagram showing 5 strings. To get the highest sound, I would pluck string number (1, 2, 3, 4, 5).



3. Shadows

Bob attached a light to a pole. The light could be attached in different positions up and down the pole. He placed an object in front of the pole. He measured the length of the shadow cast by the object when the light was straight behind the object and when it was at different heights above the object.



He concluded that the more the light was above the object and shining down on it, the shorter its shadow was.

Directions: From what he had learned, here are some things Bob might say.

Circle the word or words that make each statement true.

1. From sunrise to noon the shadows of trees in the garden will (get longer, get shorter, stay the same).

2. From sunrise to sunset the shadow of the flagpole at school (changes length, stays the same length).

3. If I use the lamp on my desk instead of the one in the ceiling above my desk my shadow will be (longer, shorter, the same length).

4. There is a streetlight at the corner. Under it the light is coming from above. Down the block it comes from the side. If I stand in front of the second house down the street my shadow will be (longer than, shorter than, the same as) it is at the corner.

4. Bicycles

Mary, Tom and Richard decided to compare a number of bicycles. They measured the diameter of the wheels and how far each bicycle travelled with one turn of the pedal arm.

Here are the notes they made:

Bicycle Number	Make	Diameter of Wheel	Distance Travelled with One Pedal Turn
1	Sekine	60 cm	180 cm
2	Sekine	66 cm	200 cm
3	Sekine	72 cm	220 cm
4	Raleigh	60 cm	180 cm
5	Raleigh	66 cm	200 cm
6	Raleigh	72 cm	220 cm
7	Centurion	60 cm	180 cm
8	Centurion	66 cm	200 cm
9	Centurion	72 cm	220 cm

They concluded that as the diameter of the wheel got longer the bicycle travelled further with one turn of the pedal arm.

Directions: From what they have learned, here are some things they might say.

Circle the word or words that make each statement true.

1. If a bicycle has a wheel diameter of 54 cm then with one turn of the pedal, it will travel (180 cm, more than 180 cm, less than 180 cm).

2. If a bicycle has a wheel diameter of 80 cm, it will travel with one turn of the pedal arm (220 cm, more than 220 cm, less than 220 cm).

3. Bicycles made for children have smaller wheels than bicycles made for adults. For each turn of its own pedal:

   (a) the child's bicycle would go farther
   (b) the adult's bicycle would go farther
   (c) they would each travel the same distance.

4. To keep pace with an adult on an adult's bicycle, a child on a child's bicycle must pedal:

   (a) faster
   (b) slower
   (c) the same speed.

5. Water Currents

Some students floated objects like leaves, twigs and dry mud particles in Jackson Park Creek. They wanted to know whether the current was fastest down near the bottom of the water, up on the surface--at the edge, or on the surface--in the centre of the creek.

Here are their results:

	Rate of Travel - cm/second
Surface of water in the middle	20
Surface of water at edges	15
Near bottom of creek	13

They concluded the current of the creek was fastest on the surface in the middle of the creek, next on the surface at the edges and slowest near the bottom.

Directions: Their teacher asked them to complete the following statements remembering what they had learned.

Circle the words that make each statement true.

1. A diver is drifting underwater down the river. A sunbather on an air mattress is drifting down the surface. The diver's speed will be (faster, slower, no different) than the sunbather's.

2. A piece of dead wood is floating slowly along the edge of a river. Suddenly, it begins to move faster. It most likely has:

   (a) sunk to the bottom
   (b) been carried to the centre of the stream
   (c) stayed at the edge.

3. A ship on the ocean wishing to travel at the fastest possible speed would:

   (a) get in the middle of a current
   (b) stay at the edge of a current
   (c) get away from the current altogether.

4. A submarine is travelling underwater in the ocean. A ship is travelling above it in an ocean current. The submarine will get (more help, less help, the same amount of help) from the current.

6. Plants (Fertilizer)

A group of students did some experiments on the growth of beans. They added different amounts of fertilizer to different plants.

Here are their results:

Amount of Fertilizer Added Once a Week	Height of Plants In 2 Months
none	10 cm
2 g	14 cm
4 g	18 cm

They concluded that the more fertilizer they added the higher the plants grew.

Directions: From what they have learned, here are some things they might say.

Circle the words that make each statement true.

1. If bean plants are given 3 g of fertilizer every week, they would likely:

   (a) grow to be more than 14 cm tall
   (b) grow to be less than 14 cm tall
   (c) grow to be about 14 cm tall.

2. If bean plants grow to be 12 cm tall after two months they most likely have been given:

   (a) less than 2 g of fertilizer daily
   (b) 2 g of fertilizer daily
   (c) more than 2 g of fertilizer daily.

3. Roses given 2 g of fertilizer each week will likely grow (more than, less than, the same as) roses given 4 g of fertilizer every week.

4. Trees probably need more fertilizer than beans. But if we knew how much to give them, fertilized trees would grow (bigger than, smaller than, the same as) unfertilized trees.

7: Plants (Water)

Terry studied how well bean plants grew with different amounts of water.

Here are the results he got:

Amount of Water Per Day	Height of Plants In 2 Months
2 mL	10 cm
3 mL	12 cm
4 mL	14 cm
5 mL	16 cm

He concluded that the more water his plants were given the taller they grew.

Directions: From what he had learned, Terry might say the following things.

Circle the words that make each statement true.

1. Plants that get 1 mL of water each day should reach in 2 months a height of (more than 10 cm, 10 cm, less than 10 cm).
2. Plants that get 2.5 mL of water per day should reach a height of (more than 10 cm, 10 cm, less than 10 cm).
3. Unless it is cut, grass should grow longer if it (rains a lot, rains a little bit, doesn't rain at all).
4. I would expect, from the results of my experiment, that plants growing at the edge of a creek would grow (taller than, shorter than, the same height as) plants further away from the water.

8. Plants (Sunlight)

Ed grew some bean plants in pots. Some of his plants were in a room where they got sunlight 12 hours a day. Others were in a room where they got sunlight for only 6 hours a day. The plants in the sunniest room were 24 cm tall in two months. The other plants only grew to be 18 cm tall in the same length of time.

He concluded that the more sunlight his plants received the taller they grew.

Directions: From what he had learned, here are some things he might say.

Circle the words that make each statement true.

1. If bean plants get 9 hours of sunlight a day in two months they should grow to a height of (more than 18 cm, 18 cm, less than 18 cm).

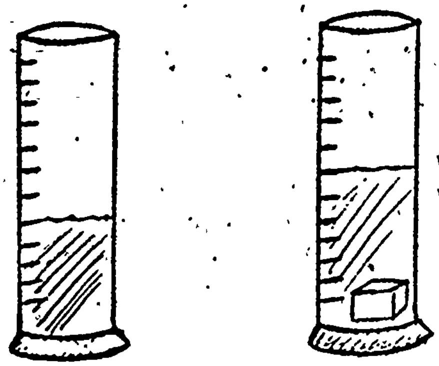
2. If bean plants grow to a height of 12 cm in two months, they are probably getting (less than 6 hours, 6 hours, more than 6 hours) of sunlight a day.

3. I should plant my garden (in an open sunny area, in a partly shaded area, in the shade among trees).

4. Suppose I planted beans outdoors about the middle of June in two places. I could plant some way up north where the sun shines almost all the time. I could plant the others near the equator. In two months the plants in the north should be (much taller than, about the same height as, much shorter than) the plants near the equator.

9. Volume and Size

Tom knows you can measure the volume of an object by measuring how much water it displaces. He wanted to know if the size of an object has anything to do with its volume. He got a narrow cylinder marked in centimeters and partially filled it with water. He noticed what mark the level was at. Then he put some objects in the cylinder, one at a time, and noticed how many centimeters the water rose each time.



Here are his results:

Object	Change in Water Level
1. Smallest - marble	2 cm
2. Medium - golf ball	4 cm
3. Largest - rubber ball	6 cm

Tom concluded that the larger the object he put in the cylinder, the greater its volume was.

Directions: From the results of his experiment, here are some things Tom might say.

Circle the words that make each statement true.

1. If I found a rubber ball that is larger than the one I used and placed it in the cylinder, the water level would rise (more than 6 cm, 6 cm, less than 6 cm).

2. If I put something round in the cylinder and the water level rose 1 cm, the object would be (smaller than, larger than, the same size as) the marble.

3. A cup is half full of water. If I wanted to make the water come close to the top of the cup, it would be best to add (a small pebble, a stone about the size of an egg, a stone bigger than an egg).

4. Suppose I measured a stick of plasticene the same way and found the water level changed 10 cm. If I rolled the plasticene into a ball and put it in the cylinder the water would rise (less than 10 cm, 10 cm, more than 10 cm).

10. Unicycles

The only boys in the neighbourhood who owned unicycles were Bob, Frank, Bill and Jack. They noticed that each unicycle wheel turned all the way around once for each complete turn of the pedal. But the wheels were different sizes. They decided to see how many complete turns of the pedal each had to make to travel 3 000 m.

Here is what they found out:

Rider	Diameter of Wheel	Distance Travelled	Number of Pedal Turns
Bob	60 cm	3 000 m	160
Frank	60 cm	3 000 m	160
Bill	66 cm	3 000 m	141
Jack	72 cm	3 000 m	123

They concluded that the larger the wheel the fewer pedal turns were needed to travel 3 000 m.

Directions: From what they had learned, here are some things they might say.

Circle the words that make each statement true.

1. If each of us travelled only one pedal turn (Frank, Jack, Bill) would go furthest.

2. If Frank, Bill and Jack travelled for 10 pedal turns they would arrive at (the same point, different points).

3. If Bob and Frank pedalled side by side, keeping pace with each other, Bob would travel (at a slower rate, at the same rate, at a faster rate) than Frank.

4. If we all went for a long ride, (Bob, Frank, Bill, Jack) would probably be least tired at the end of the trip.

5. Intermediate Division Item Pool

The items have been grouped in terms of skill, using the same sequence that was followed for the presentation of the domain definitions (growth schemes).

In each case a marking scheme precedes the items.

A. QUESTIONING - Intermediate Level

Answer Sheet

Items	Level 4	Level 5	Level 6	Level 6a	Level 7
1. Melting Ice	c	b	d	e	a
2. Pulling Force	d	a	c	b	e
3. Heat Conduction	a	c	e	d	b
4. Onion Sprouts	e	d	c	b	a
5. Irritability	b	d	a	c	e
6. Respiration	c	e	b	a	d
7. Animal Growth	a	e	d	b	c
8. Property of Matter	b	a	e	d	c
9. Thermal Expansion	d	b	a	c	e
10. Radiation and Heat Absorption	d	e	a	c	b

1. Melting Ice

A teacher placed ice in a liquid and asked the class to observe carefully what happened. Over several minutes the class noticed the ice chunks growing smaller as they melted.

Directions: The teacher told the class they could do an experiment using ice and liquid. Which would be the best question for the class to ask?

Circle the letter of your choice.

(a) Is the effect of quantity of liquid on the melting rate different for different liquids?

(b) If there was more liquid would the ice melt faster?

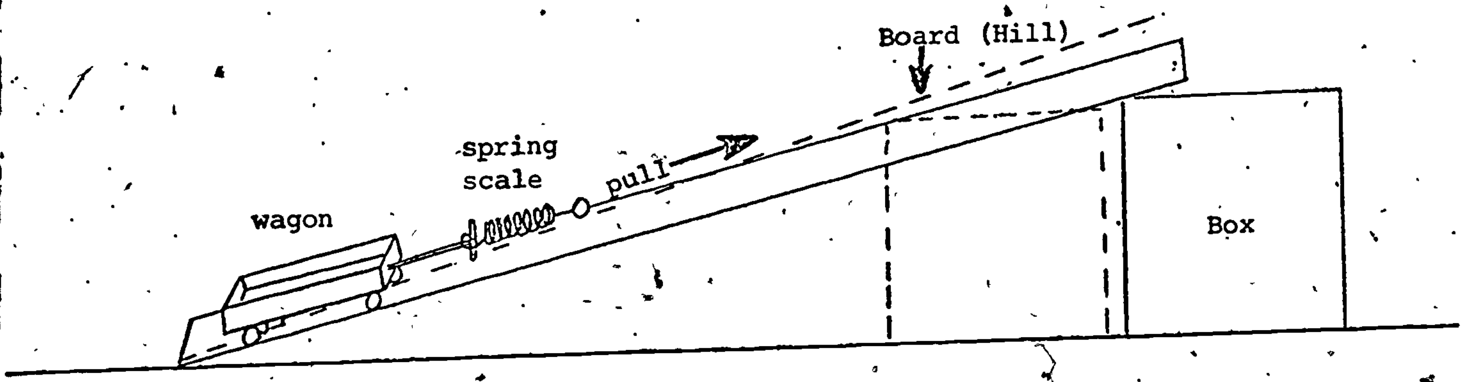
(c) How can we make the ice melt faster?

(d) Is the rate of ice melting affected by the quantity of the liquid?

(e) Does the quantity of liquid affect the rate of ice melting? Does the type of liquid affect it?

2. Pulling Force

The class made a ramp by placing one end of a board on a box. They could make a steeper ramp if they placed the box further under the board. They attached a spring scale to a little wheeled wagon. They pulled the wagon smoothly and gently up the ramp and observed the amount of pulling force shown on the spring scale.



Directions: If you were in the class which of the following questions do you think would be best for them to answer by doing an experiment?

Circle the letter of your choice.

(a) If the ramp is steeper is the pulling force increased?

(b) How does the angle of the ramp affect the pulling force needed? How does the mass to be pulled affect the pulling force needed?

(c) Does the angle of the ramp affect the pulling force needed?

(d) How can we increase the pulling force needed?

(e) Is the effect of the angle of the ramp on the necessary pulling force different for different masses?

3. Heat Conduction

Four boys were cooking the bacon and eggs at a summer camp. Each had a similar Coleman stove. Their frying pans were the same size and each had the same amount of food in his pan, yet the food in some was cooking faster than in others.

Directions: One boy said they could do an experiment. Which is the best question for them to ask?

Circle the letter of your choice.

(a) What makes the food cook faster in some pans than in others?

(b) Is the effect of metal type on heat conduction different for different thicknesses?

(c) If I use a copper pan will the food cook faster?

(d) Is the conduction of heat affected by the type of metal in the pan? Is it affected by the thickness of the pan?

(e) Is the conduction of heat affected by the type of metal in the pan?

4. Onion Sprouts

John was helping his father clean out the basement. In a dim corner they found a net bag full of onions. Most of the onions had sprouted long green shoots. All the shoots grew up through the top of the bag, even when the onion was upside down. John was puzzled.

Directions: John wanted to experiment to understand what had happened. Which is the best question for him to ask?

Circle the letter of your choice.

(a) Does the effect of the source of light on the direction of growth of the sprouts depend on the degree of humidity?

(b) Is the direction of growth of the sprouts affected by the source of light? Is it affected by the degree of humidity of the room?

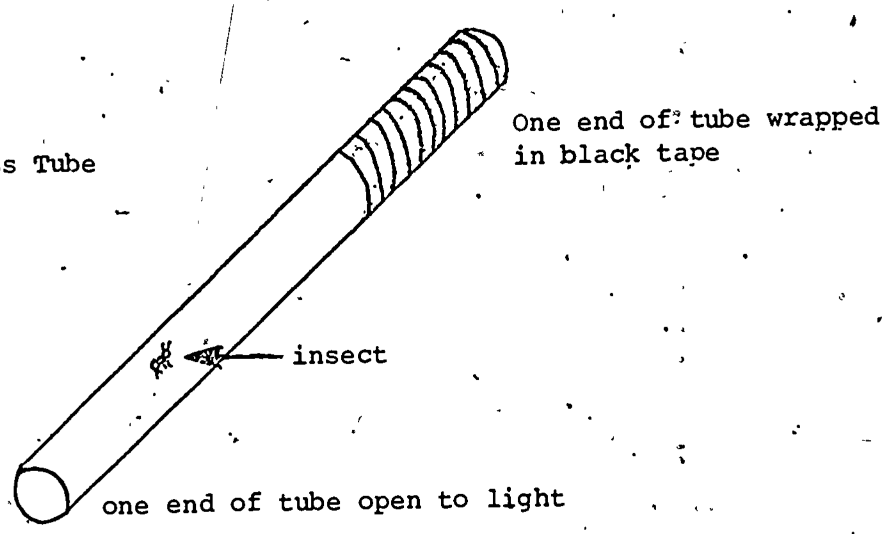
(c) Does the source of light affect the direction of growth of the sprouts?

(d) If the bag was above the window would the sprouts grow down to the light?

(e) What makes the onion sprouts grow upwards?

5. Irritability

Johnny watches ants and other insects. They look like they know where they want to go. His teacher says they may be moving towards or away from certain things in the environment.



Directions: Suppose Johnny collected some ants. Suppose he has some glass tubes to put the insects in. He can make the environment different at either end of a tube, for example he can cover one end to make it dark and leave the other end uncovered to let in light. He can make the two ends different in other ways as well. If he did an experiment, which of the following would it be best for him to ask?

Circle the letter of your choice.

(a) Does the source of light affect the direction of movement of an insect?

(b) What attracts ants so they will move towards it?

(c) Is the direction of movement of an insect affected by the source of light? Is it affected by the degree of humidity?

(d) If I let light into a dark place will the ant move towards the light?

(e) Does the effect of the source of light on the direction of movement of an insect depend on the degree of humidity?

6. Respiration

The class had a fish tank at the back of the room. They turned on a bubbler from time to time to keep air in the water. Sometimes the fish were more active than at other times and the class wondered why this should be. The teacher asked them to think of a question they could answer by doing an experiment.

Directions: Which of the following questions would be best for them to ask?

Circle the letter of your choice.

(a) Is the <u>activity</u> of the fish affected by the amount of air in the water? Is it affected by the amount of vegetation in the tank?

(b) Is the activity of the fish affected by the amount of air in the water?

(c) How can we make the fish more active?

(d) Does the effect of air in the water on the activity of the fish depend on the amount of vegetation in the tank?

(e) If we turn on the bubbler and add more air to the water will the fish get more active?

7. Animal Growth

Mr. Smith's science class got some tiny baby goldfish from a man who raised them. They wanted to take care of them so they would grow as fast as possible. They had quite a lot of little fish so Mr. Smith suggested they put a few in each of several tanks and treat each tank of fish differently.

Directions: Suppose you were a student in Mr. Smith's class. If you did an experiment, which of the following questions would be best to ask?

Circle the letter of your choice.

(a) How can we make the fish grow fast?

(b) Is the rate of growth of the fish affected by the amount they are fed? Is it affected by the kind of fish food used?

(c) Does the effect on the rate of growth of the amount the fish are fed depend on the kind of fish food used?

(d) Is the rate of growth of the fish affected by the amount they are fed?

(e) If we feed the fish more will they grow faster?

8. Property of Matter

Bill's uncle didn't feel very well. Bill watched his uncle put two tablets of Alka-Seltzer in a glass of water. The water got full of bubbles before his uncle drank it. Bill thought this was interesting and wanted to know more about it.

Directions: Suppose Bill got a package of Alka-Seltzer tablets and took them to school. At school he could use the beakers and other equipment in the science room to do an experiment. Which of the following questions would it be best for Bill to ask?

Circle the letter of your choice.

(a) -If I warm the water will I get more bubbles?

(b) How can I make the tablets create more bubbles?

(c) Is the effect of the temperature of the water on the amount of bubbles produced different for different quantities of water?

(d) Is the quantity of bubbles produced affected by the temperature of the water? Is it affected by the quantity of water?

(e) Does the temperature of the water affect the quantity of bubbles produced?

9. Thermal Expansion

One day a student left a corked test tube which was completely filled with a liquid on a sunny windowsill. Suddenly the cork flew out and the liquid spilled. The liquid must have expanded (taken up more space) and pushed out the cork.

Their teacher told the class they could do an experiment to find out more about what had happened.

Directions: Which would be the best question for the class to ask?

Circle the letter of your choice.

(a) Is the amount of expansion affected by the temperature of the liquid?

(b) If we heat the liquid will it expand?

(c) Does the type of liquid affect the amount of expansion? Is the amount of expansion affected by the temperature of the liquid?

(d) How can we make a liquid expand?

(e) Is the effect of temperature on the amount of expansion different for different liquids?

10. Radiation and Heat Absorption

On a warm sunny day Jim and his father went to buy an aluminum garden shed. They inspected several models set up outside the store. Jim noticed that it felt much warmer inside some of them than in others.

He mentioned this to his teacher who told him he might do an experiment. He said Jim could use empty aluminum juice cans to represent the sheds and a large lamp to represent the sun.

Directions: Which would be the best question for Jim to ask?

Circle the letter of your choice.

(a) Is the colour of the finish related to the amount of heat absorbed through the metal?

(b) Do the colour and shininess of the finish together affect the amount of heat absorbed through the metal?

(c) Is the amount of heat absorbed through the metal affected by the colour of the finish? Is it affected by the shininess of the finish?

(d) How can we make it hotter inside some of the cans?

(e) If we paint some of the cans a dark colour will they get hotter inside?

B. DEVELOPING A PLAN - Intermediate Level

Answer Sheet

Items	Level 2	Level 3	Level 4	Level 5
1. Conduction	d	a	b	c
2. Irritability	c	b	a	d
3. Ramp	d	c	b	a
4. Spring and Wagon	b	d	a	c
5. Metal Springs	a	d	c	b
6. Thermal Expansion	d	c	b	a
7. Pendulum	c	a	d	b
8. Radiation and Heat Absorption	d	a	c	b
9. Fish	b	c	d	a
10. Onions	a	d	b	c

Developing A Plan

Intermediate

1. Conduction

You are asked to cook dinner at summer camp. You have a number of pots and several single burner Coleman stoves. You put water in the pots and put them on the stoves. Some come to a boil before the others. You wonder why.

Directions: You decide to find out more. Here are some ideas about what you could do. Which one is best?

Circle the letter of your choice.

(a) Put some water in two pots that are different thicknesses. Put each on a different stove and turn on the burners. Note the time it takes each to come to a boil. See if it's different. You might try doing it again to see if the same pot boils first a second time.

(b) Pick out two pots that are the same size and the same metal, but different thicknesses. Put the same amount of water in each. Be sure it is the same temperature. Put each on a stove. Turn each stove on the same amount at the same time. See in which pot the water comes first to a full rolling boil.

(c) Find two pots that are the same size and the same metal but different thicknesses. Find two more, of a different metal but the same size and thicknesses as the first two. Put the same amount of water of the same temperature in each. Start heating each pot at the same time with the burner of each stove you use turned on the same amount. See in which metal or thickness of pot the water comes first, second, third and fourth to a full rolling boil.

(d) Fill a pot with water. Put it on a stove. Turn on the burner. See if it comes to a boil. Change the amount of water and try that. Do it again on another stove. Try one of the other pots. See what you notice when you do that. Keep trying different things.

2. Irritability

You have watched insects crawling or flying around. They seem to know what they are doing. Your teacher says maybe something in the environment attracts or repels them.

You have some glass tubes. Each is open at both ends. Along the upper surface is a small hole. You have some ants and other insects such as mealworms and wood lice you can put in the tubes.

You also have some dark paper and transparent paper to cover the ends of the tubes.

Directions: Here are some ideas about what to do with this equipment. Which one is best?

Circle the letter of your choice.

(a) Cover one end of a tube with dark paper. Cover the other end with transparent paper. Be sure both papers are very dry and have the same odour and temperature. Put in an ant and watch to see the direction it goes. Repeat in exactly the same way with several more ants in case the first one was not healthy and see if they do the same thing.

(b) Cover one end of a tube with dark paper. Cover the other end with transparent paper. Put an ant in the tube. Watch to see which direction it goes. Shake the tube and then see what direction it goes. Put the tube in other places and see if the ant still goes in the same direction when you set it down.

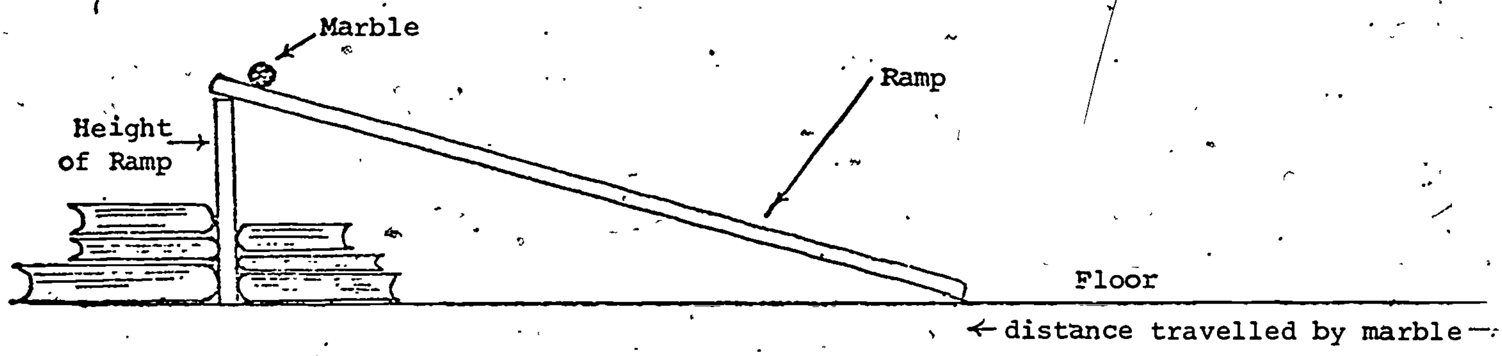
(c) Use one of your materials to cover one end of a tube. Use the other one to cover the other end. Put an ant into the tube. Watch to see what happens. Add another ant. Watch again. Put in a mealworm or a wood louse. Watch again. Change the material covering one of the ends and watch. Keep changing or adding insects and watch.

(d) Prepare three tubes with dark paper on one end and transparent paper on the other. Be sure the papers are the same temperature, odour and dryness. Put an ant in one tube, a mealworm in the second and a wood louse in the third. Watch to see which direction each goes. Repeat the experiment several times with different ants, mealworms and wood lice. See if they all go the same or different directions.

3. Ramp

Richard saw his friends rolling marbles down a ramp they had built using boards and books. They were trying to get the marble to reach a certain mark on the floor. The mark was quite a long distance from the ramp and none of their marbles reached it.

Richard built a ramp of his own just the same as theirs. He got some marbles of different masses.



Directions: Here are some ideas for what Richard could do with his equipment. Which one is best?

Circle the letter of your choice.

(a) Roll a small 1 g marble several times down a ramp that is 10 cm high, starting it the same way each time. Repeat this step with the same marble and ramps 12 cm and 14 cm high. Take a 2 g marble and then a 3 g marble and repeat the experiment with each of them. Use all 3 ramp heights with each of the marbles. Measure the distance rolled each time. Compare all the distances.

(b) Roll one marble several times down a ramp that is 10 cm high. Start it from the same spot and the same way each time. Raise the ramp to 12 cm and then 14 cm and roll the same marble several times down each of them. Do it the same way. Measure how far it rolls each time and compare the distances from different heights.

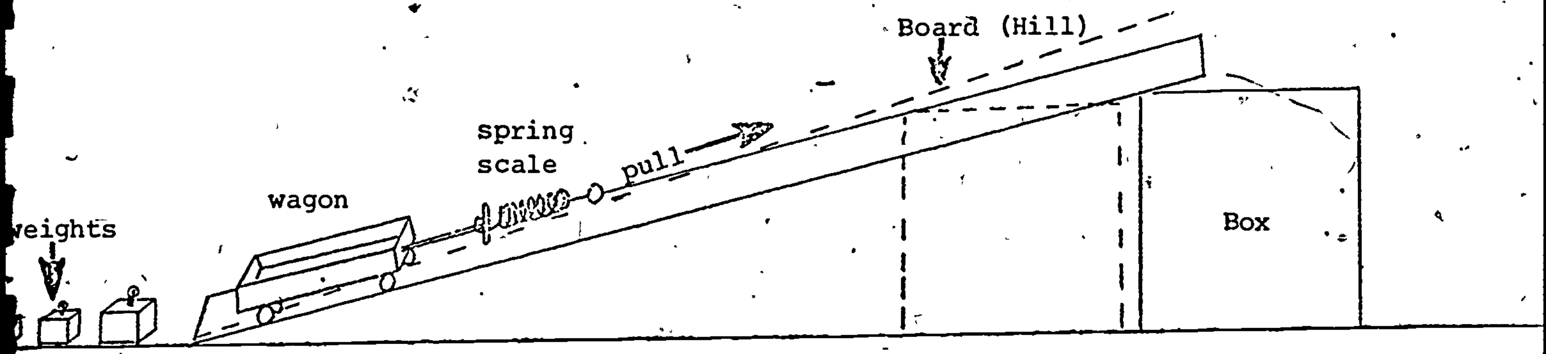
(c) Roll some marbles down a ramp that is 10 cm high. Raise the ramp to 12 cm and roll some more. Raise it again to 14 cm and roll some more. Measure how far the marble goes each time and compare the distances from the different heights. Use coloured chalk to mark how far each marble goes.

(d) Roll a lot of marbles down the ramp. Use different masses. Try changing the height of the ramp by using a bigger board to hold it up. Try something a little different each time he rolls another marble to see what happens. Keep doing this.

4. Spring and Wagon

Some students agreed it takes force to make a vehicle go up a hill.

To learn more they built a hill by leaning a long board on a box. The hill could be made steeper by moving the box further under the board. They had a little wagon and some different weights to load it. A spring scale could be attached to the wagon to measure the pulling force.



Directions: Here are some ideas about what they could do with their equipment. Which do you think is best?

Circle the letter of your choice.

(a) Put one of the weights in the wagon and place it at the bottom of the hill. Mark off a 1 metre distance on the hill. Attach the scale and pull the wagon slowly and smoothly to this point. Shift the box two or three times to make the hill steeper, repeating the pull exactly the same way each time. Compare the pulling forces required each time.

(b) Put the wagon at the bottom of the hill. Attach the scale and pull. Put in a weight and repeat. Change or add weights if desired. Also if desired, change the height of the hill by shifting the box. Take turns pulling the wagon. Watch carefully and make notes of all observations.

(c) Put the smallest weight in the wagon. Attach the spring scale to the wagon. Starting it from the same place at the bottom of the hill each time and pulling it slowly and smoothly a 1 metre distance each time, measure the pulling force required for several steepnesses of the hill. Repeat all these steps two or three times with more weights in the wagon and compare all the pulling forces required.

(d) Put one of the weights in the wagon. Start the wagon near the bottom of the hill. Attach the scale and pull. Measure the pulling force required. Shift the box to make the hill steeper and repeat. Shift it again to make it even steeper and repeat again. Compare the pulling forces required.

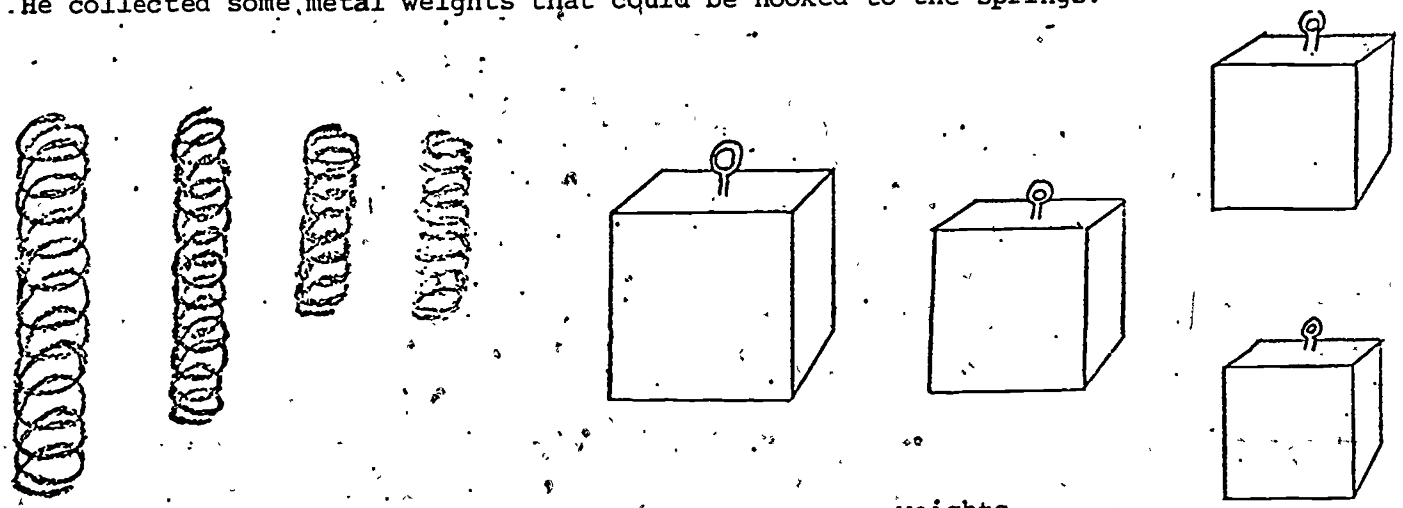
Developing A Plan

Intermediate

5. Metal Springs

Johnny found some old springs in his father's workshop. Some seemed heavier and harder to stretch than others.

He collected some metal weights that could be hooked to the springs.



Directions: Here are some ideas for what Johnny might do with this equipment. Which one is best?

Circle the letter of your choice.

(a) Hang the springs from hooks on the wall. Pull on them with his fingers to see how they feel. Attach a weight to one of them. Try a different weight on another. Keep moving weights around on the springs. Watch carefully and keep notes.

(b) Hang the springs from hooks on the wall, making sure the hooks are big enough to let each spring hang free. Measure the length of each spring. Using different weights one at a time, attach the weight smoothly and carefully to one of the springs. Each time, measure its length now. Repeat, using all the same weights, on the other springs. Compare the amount each spring stretches with each of the weights.

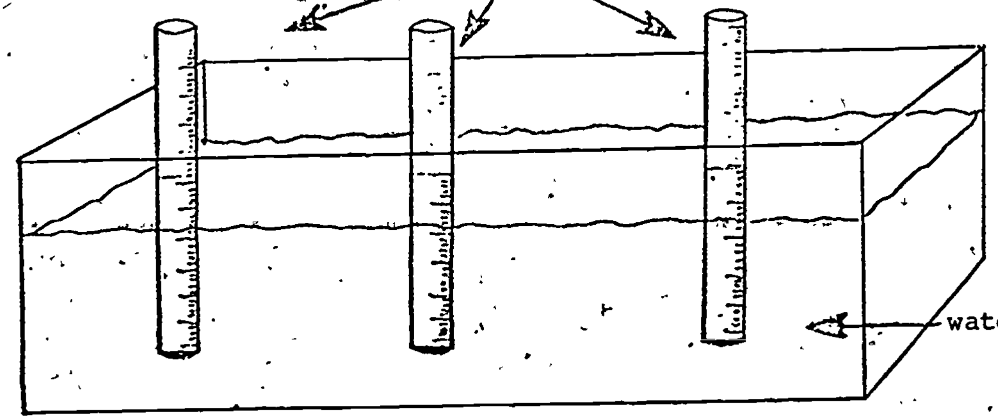
(c) Hang the springs from hooks on the wall. Be sure each spring hangs free of the wall. Measuring the length of the spring before and after, attach one of the weights to each spring in turn. Attach the weight carefully and do it the same way each time. Compare the amount each spring stretches.

(d) Hang the springs from hooks on the wall. Measure the length of the spring. Take one weight and hang it to the spring. Measure the length of the spring now. Measure the length of the next spring. Move the weight to it. Measure it now. Do this for all the springs. Compare the amount each spring stretches.

6. Thermal Expansion

One day a student left a corked test tube which was completely filled with water on a sunny windowsill. Suddenly the cork flew out and the water spilled. The teacher said the water had pushed out the cork because it had expanded (taken up more space) as it heated in the sun.

The class wanted to know more. Would that always happen? Suppose they had a large pan which could be filled with hot water. They had three thin glass cylinders marked in millilitres and some different liquids.



Directions: Here are some ideas about what they could do with their equipment. Which one is best?

Circle the letter of your choice.

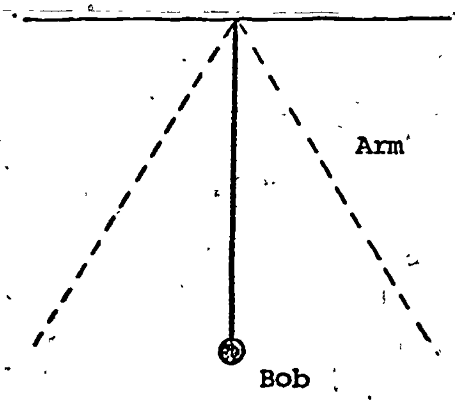
(a) Cool the different liquids to the same temperature in the refrigerator. Partly fill each cylinder to the same mark with a different liquid in each. Heat the water bath to a moderate temperature and place the cylinders in it, upright, for 5 minutes each. Note the levels now. Using new samples of the liquids, after cooling the cylinders, repeat with a very hot water bath. Compare all the levels reached.

(b) Cool the liquids to the same temperature in the refrigerator. Partly fill each cylinder to the same mark with a different liquid in each. Heat the water bath to a high temperature. Place the cylinders upright in the bath. After each has been in five minutes compare the height of the liquid in the different cylinders.

(c) Partly fill each cylinder with a different liquid. Mark the level in each cylinder. Place them upright in the hot water bath for a while. See if the liquid level is now higher in any of the cylinders.

(d) Put a different liquid in each cylinder, maybe water, vinegar and corn oil. Place the tubes in the hot water bath for a few minutes. Watch the liquids carefully. See what they do. Before trying more liquids in the same cylinders, empty them and clean them carefully.

7. Pendulum



Pendulum

There is a grandfather clock in the front hall of the school. Some students wondered how it works. A teacher said it works by means of a pendulum that moves back and forth. A pendulum can be made using a mass (bob) and a string.

Directions: Here are some ideas about how to study the principles on which the pendulum works. Which is the best?

Circle the letter of your choice.

(a) Attach the bob to the string. Measure the time it takes for the pendulum to go from side to side (the period). Lengthen the string. See if the period is changed. Do this several times.

(b) Attach a 1 g bob to the string and swing it back and forth. Use a string length of 10 cm, then 20 cm and then 30 cm. Measure the time it takes for the pendulum to move back and forth (the period) with each string length. Repeat, starting each swing from the same point, using bobs of 5 g and then 10 g and compare all the periods.

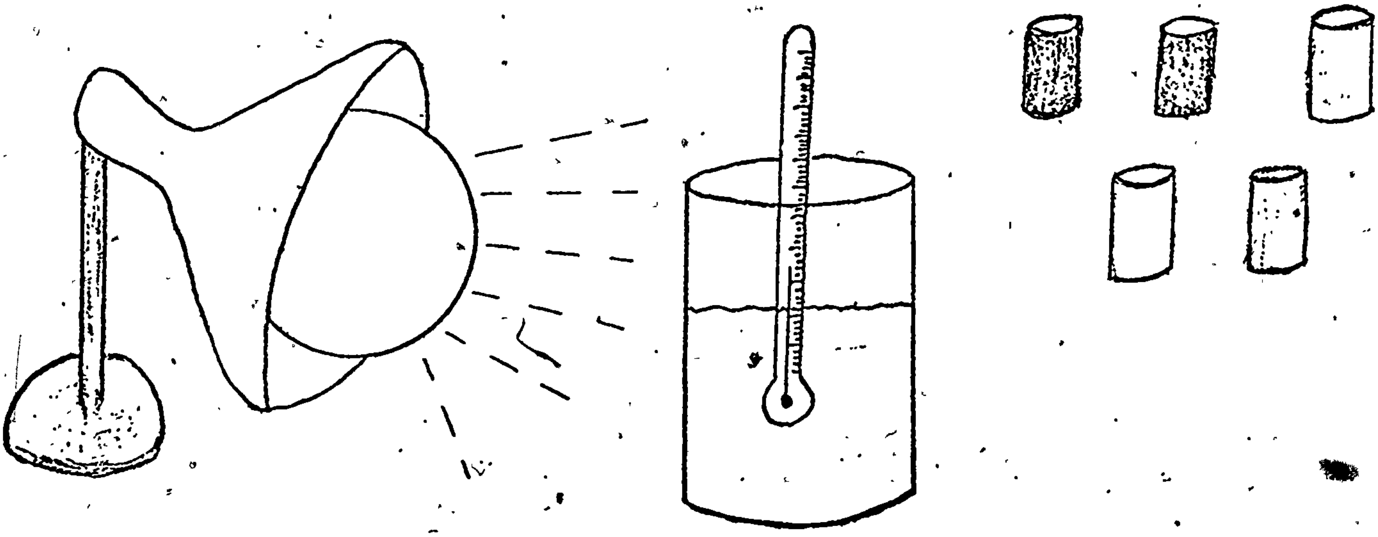
(c) Attach the bob to the string. Suspend the bob so that it can swing back and forth. Swing the bob several times. See if you can be careful enough to make it swing smoothly. Watch the pendulum swinging and see if you can learn something about it.

(d) Attach a 1 g bob to the string and swing it back and forth. Start each swing from the same point. Measure how long it takes for the pendulum to go from one side to the other (the period). Use a string of 10 cm and then repeat using a string of 20 cm and compare the periods.

8. Radiation and Heat Absorption

On a warm sunny day Jim and his father went to buy an aluminum tool shed. They inspected several models set up outside the store. They found two similar models that they liked but Jim noticed that it felt much warmer inside one of them. He wondered about this.

Jim collected empty juice cans with the labels removed to represent tool sheds and a 250 watt lamp to represent the sun. He had a thermometer to measure the temperature.



Directions: Here are some ideas for what Jim could do with his equipment. Which is best?

Circle the letter of your choice.

(a) Paint one can black, one white and one green. Put some water in each of them. First shine the lamp on the black can and see if the water gets hot. Take the temperature of the water. Shine the lamp on the white can, and then the green one. See if the water gets hotter in one of them.

(b) Paint 2 cans black, two white and two green. Use shiny enamel paint for one can of each colour and dull flat paint for the other one. Taking each can in turn, put 1/2 litre of water in it and place it 20 cm from the lamp for half an hour. Be sure the water temperature in each can is the same at the beginning of its turn. Measure the temperature again at the end. Compare the water temperature reached in the 6 cans.

(c) Paint one can black, one white and one green. Use shiny enamel paint for each. Taking each can in turn fill it exactly half full of water. Measure the water temperature and be sure it's the same in each one before it is placed 20 cm from the lamp for half an hour. Measure the temperature again at the end of that time. Compare the water temperatures reached in the 3 cans.

(d) Put some water in an empty juice can. Hold the base of the lamp in his hand. Shine it on the can. Try holding the lamp closer or farther away. See what happens to the water in the can. Try it with a different can. See what happens with it.

9. Fish

Sue's class were studying the breathing mechanisms of several different kinds of animals. Sue had noticed that the mouth and gill movements of a fish were sometimes faster than at other times. She wondered how certain conditions affect breathing rate.

She got some fish bowls and some goldfish. She got a bottle of vinegar. Vinegar is a mild acid.

Directions: Here are some ideas for what Sue might do with this equipment. Which one is best?

Circle the letter of your choice.

(a) Let a pail of tap water settle. Warm 1 000 mL to 20°C and put it in one bowl. Add 3 fish. Count the number of times each fish opens and closes its mouth (the number of breathing movements) in one minute. Do this in the plain water and again after adding first 10 mL of vinegar and then 40 mL more vinegar to the bowl. Gradually adapt the fish to warmer water. Place them in a second bowl containing 1 000 mL from the same pail warmed to 30°C. Repeat the counts without and with vinegar. Compare all the breathing counts.

(b) Put water in two fish bowls. Make sure it's not too hot or too cold for the fish. Put some fish in each bowl. Put a little bit of vinegar in one of the bowls. Get a notepad and make notes of how the fish behave in the different bowls. Do it several times if you want. Change the amount of vinegar and see what happens.

(c) Put water from the tap in two of the bowls. Make sure it's not too cold or the fish might die. Put a fish in each bowl. Add 10 mL of vinegar to one bowl. Count the number of times the fish opens and closes its mouth (the number of breathing movements) in one minute. Do this for both fish and compare. Repeat if you think you could have made a mistake.

(d) Let a pail of tap water settle. Warm 1 000 mL to 20°C and place in a bowl. Add 3 fish. Count the number of times each fish opens and closes its mouth (the number of breathing movements) in one minute. Add 10 mL of vinegar to the water. Count each fish's breathing movements in one minute again. Add 40 mL more vinegar. Again count the breathing movements in one minute and compare with the other counts.

10. Onions

John helped his father clean out a storage room in the basement. In a dim corner they found a net bag full of onions. Most of the onions had sprouted long green shoots. All the shoots grew up through the top of the bag, even when the onion was upside down. John was puzzled.

He went to the store and bought a large bag of onions. There was an empty closet in the house. It had an electric outlet on one wall.

Directions: Here are some ideas for what John could do with the onions. Which one is best?

Circle the letter of your choice.

(a) Plug in a night light to give a dim light in the closet. Put onions all around on the floor. Put some on the shelf in the closet. Tie a string around some and hang them from the ceiling if you want. Look everyday to see what the onions are doing.

(b) Plug in a night light. Get 12 onions the same size with no sprouts. Put 6 on the floor with the top of each pointing in a different direction. Tie strings around the others. Hang them from the ceiling right above the first ones. Make sure they are the same distance from the light as the onions on the floor. Make sure the tops point in the same directions. Check once a week and compare the direction the sprouts grow.

(c) Plug in a night light. Get 12 onions the same size with no sprouts. Put 6 on the floor. Make the top of each point in a different direction. Hang the others from the ceiling right above them, the same distance from the light and pointing in the same directions. When those have sprouted enough to see what direction the sprouts are growing, repeat with 12 more onions. This time keep pails of water in the closet to make it damp. Compare these onions with the first ones.

(d) Plug in a night light. Put an onion on the shelf. It will be above the light. Put another on the floor. It will be under the light. Check once a week. When the onions sprout compare the direction the sprouts are growing. Do it over again with more onions if you want.

C. JUDGING THE ADEQUACY OF DATA - Intermediate

Answer Sheet

1. c
2. c
3. d
4. d
5. c

6. a
7. c
8. d
9. d
10. c

11. a
12. c
13. c
14. c
15. c

16. a
17. b
18. c
19. b
20. b

21. d
22. d
23. c
24. c
25. a

26. c
27. b
28. c
29. c
30. d

31. d
32. e
33. b
34. b
35. d

36. b
37. d
38. a
39. d
40. d

41. d
42. c
43. a
44. c
45. c

46. b
47. e
48. b
49. c
50. a

51. b
52. d
53. a
54. c
55. c

56. c
57. e

1. Bill wanted to know if all bean seeds have the same mass. He should use a balance which can be read to the nearest:

   (a) gram

   (b) kilogram

   (c) 0.1 gram

   (d) milligram = 0.001 gram

2. Jim wanted to measure the daily growth of a newly germinated bean seed. He should use a ruler which can be read to the nearest:

   (a) metre

   (b) centimetre

   (c) millimetre

   (d) 0.5 centimetres

3. Bob and Anne were measuring the weight of a piece of metal using spring scales. They recorded their values in the table below.

Trial	Anne's Measurements	Bob's Measurements
1	5.0 N	4.8 N
2	4.9 N	4.7 N
3	5.0 N	4.8 N
4	5.1 N	4.9 N
5	5.0 N	4.8 N
Average	5.0 N	4.8 N

   Which of the following factors might account for the different answers.

   (a) one of the spring scales was not "zeroed" (reading zero) at the beginning of the measurement

   (b) either Anne or Bob was not reading the scale at eye level

   (c) one of the spring scales has lost some of the "tightness" of its coil

   (d) possibly any of the above

4. A graduated cylinder was used by four students to determine the volume of an irregularly shaped object by water displacement. Each student recorded a different answer. Which factor may have accounted for this?

(a) the level of the water was not read at eye level

(b) the cylinder was held at an angle as the water level was read

(c) the object was not lowered carefully into the cylinder and water splashed out.

(d) possibly any of the above

5. A graduated cylinder with a scale marked every 1.0 mL was used to find the volume of a thumb tack. This procedure would result in:

(a) an inaccurate answer

(b) an accurate answer

(c) no answer

(d) an answer that was close to the actual value

6. In order to discover the volume of one thumb tack, which procedure would be best to use?

(a) use a graduated cylinder marked every 1.0 mL but use 100 thumb tacks at once, then divide the increase in volume by 100

(b) use a graduated cylinder marked every 1.0 mL and repeat the procedure with one tack ten times, then calculate the average

(c) use a graduated cylinder which has a scale marked every 0.5 mL and take one measurement with one tack

(d) use a mathematical formula to suit the shape of a thumb tack and calculate the volume

7. A class wanted to discover the effect of exercise on the rate of the heart beat. Each student needed to measure his own "resting" heart rate by taking his pulse. The best data would be obtained by:

(a) taking one 60 second pulse rate using the first two fingers of your right hand on the bottom of your left wrist

(b) taking one 60 s pulse rate using the first two fingers of your right hand on your throat, half way between your voice box and corner of your jawbone

(c) taking several 60 s readings using either method above and averaging the results

(d) taking several 5 second readings using either method above, multiplying by 12 to give 60 second readings, then averaging

8. Four students calculated (independently) the volume of the same box by measuring the length, width, and height and using the formula V = L x W x H. Their results are given in the table below.

Student	Volume
1	160 cm^3
2	150 cm^3
3	160 cm^3
4	200 cm^3

Would you:

(a) find the average volume using the four values given in the table

(b) find the average volume using the first three values and throwing out the last one

(c) have the students repeat their measurements and calculations, then average the 8 results

(d) have the students check their measurements and calculations and if student 4 gets a value closer to the values of the other three, then average the four values

9. Wendy is interested in learning about the structure of the willow tree flower. She should:

(a) find a willow tree and examine a flower

(b) find a willow tree and examine several flowers

(c) examine one flower on several different willow trees

(d) examine several flowers on several different willow trees

10. Paul notices that water in a pot sitting on a stove element is bubbling. Would he:

(a) conclude that the water is definitely boiling

(b) conclude that the water is definitely not boiling

(c) make no conclusions until further observations were made

(d) conclude that the water in the pot is probably boiling.

11. When determining the factors that may affect the degree of friction when a block slides across a table, the least important consideration in the list below would be:

(a) the colour of the block

(b) the mass of the block

(c) the type of surface on the block

(d) the type of surface on the table

12. In order to discover the thickness of one sheet of paper in a book, you should:

(a) find a ruler with a scale small enough to measure the thickness of one sheet

(b) try to measure the thickness of 10 sheets in millimetres and divide by 10

(c) try to measure the thickness of 100 sheets in millimetres and divide by 100

(d) try to measure the thickness of 100 sheets in centimetres and divide by 100

13. Peter set up an experiment to try to prove that male mice could learn faster than female mice, because he thought males were smarter than females. His data seemed to indicate that male mice would find their way through a maze faster than female mice. Would you:

(a) accept Peter's data and conclude that male mice could learn faster than female mice

(b) accept Peter's data and conclude that the male of most animal species can learn faster than the female

(c) look for flaws in Peter's procedure since you suspect sex has no bearing on how quickly animals learn

(d) repeat Peter's experiment exactly and if you get the same results conclude that male mice learn more quickly than female mice

14. On viewing the great number of dandelions on her front lawn, Mary wondered if they grew any taller in one area than in another. She decided to divide her lawn into eight equal squares using pegs and string. To see if the taller dandelions were located in a specific area of the lawn she should:

(a) measure the tallest dandelions in each square

(b) measure one of the tallest and one of the shortest dandelions in each square and find the average

(c) select 20 dandelions in each square, chosen at random with eyes closed, measure the size and find the average size for each square

(d) inspect by eye each square and decide which 2 squares have most of the taller dandelions

15. Frank took the "resting" pulse (heart beat) of the 30 students in his class. His values ranged from 55 beats per minute to 115 beats per minute. He should:

(a) not worry about the variation and just find the average

(b) conclude that his technique for taking the pulse is not good

(c) check with a doctor to see if such a variation is normal

(d) count only those which are within 10 beats per minute of the normal resting pulse which he had heard was 72 beats per minute

16. Linda wanted to use five identical marbles for an experiment. She bought 5 which looked identical from the same box in a store but she decided to check the mass of each using a balance. She got the following measurements:

Marble	Mass
1	5.25 g
2	5.00 g
3	5.50 g
4	4.75 g
5	5.25 g

What should she first do?

(a) assume that the balance may not be working properly and repeat her measurements with another balance

(b) not worry about the differences and just use the average mass value when using each marble

(c) conclude that the marbles are not identical in size

(d) conclude that the marbles are made from different types of glass

17. Fred was attempting to discover if there was any relationship between the mass of a substance and its volume. He measured the mass and volume of twelve different sized chunks of aluminum and divided the mass value by the volume value for each chunk. Eleven answers were within 50 kg/m^3 of 2 100 kg/m^3. One answer was out by 500 kg/m^3. Fred should:

(a) omit the answer that was out by 500 kg/m^3 and average the rest

(b) repeat the measurements and calculations for all samples with particular emphasis on the one that was out by 500 kg/m^3

(c) average the twelve answers as they stand

(d) scrap the experiment because none of the calculated values was identical

18. Fred was attempting to discover if there was any relationship between the mass of a substance and its volume. He measured the mass and volume of twelve different sized chunks of aluminum and divided the mass value by the volume value for each chunk. Eleven answers were within 50 kg/m^3 of 2100 kg/m^3. One answer was out by 500 kg/m^3. Fred checked his measurements of the odd sample several times and got the same result. Fred should:

(a) scrap the experiment

(b) ignore the one that was out by 500 kg/m^3

(c) look for other reasons why one sample was so far out

(d) average all twelve results

19. Bob wanted to compare the height of the maple trees and beech trees in a wooded area. He should:

(a) measure the heights of the tallest maples and tallest beech trees and compare

(b) choose, at random, several maple trees and several beech trees and compare their heights

(c) find the average height of several maple trees in one area of the forest and the average height of several beech trees in another area of the forest and compare

(d) walk to several different areas in the forest and estimate by eye which trees seem to be taller, maples or beech

20. Cheryl wanted to find out what makes some solid balls bounce higher than others. Which list of factors below should she consider in her experiment?

(a) the mass, volume, and material of the ball

(b) the mass, volume, and material of the ball and the height from which it is dropped

(c) the mass and volume of the ball and the height from which it is dropped

(d) the volume and material of the ball and the height from which it is dropped

(e) the mass, volume and material of the ball, the country where it was made and the height from which it is dropped

21. Bill wanted to write a report about mealworms. The best report would be based upon:

(a) reading reference books about mealworms

(b) reading reference books about mealworms and observing one in a glass dish

(c) observing a mealworm in a glass dish

(d) reading reference books about mealworms and observing several in a glass dish

22. Carole had thought of an interesting theory to explain how birds migrate in the right direction at the right time of the year. As a good scientist she should:

(a) read only reference books which support her idea

(b) set up an experiment so that it supports her idea

(c) read several reference books to get as many ideas on the subject as possible

(d) read several reference books on the subject, set up an experiment, then decide if her idea is correct, partly correct, or incorrect

23. Andrew carried out an experiment which gave some data he did <u>not</u> expect. He should:

(a) accept all the data of the experiment

(b) repeat the exact experiment, then accept all the data

(c) check with a reference, perhaps his teacher, concerning the design of his experiment, then experiment again

(d) ignore the data which was unexpected and draw conclusions from the rest of the data

24. Sam found the length and width of a piece of paper to be 5.10 cm and 7.25 cm respectively. He should report the area of the paper as being:

(a) 36.975 cm^2

(b) 37 cm^2

(c) 37.0 cm^2

(d) 36.96 cm^2

25. When measuring the length of a line using a ruler marked every half cm you could report the length in cm:

(a) to two decimal places of accuracy

(b) to one decimal place of accuracy

(c) to three decimal places of accuracy

(d) to no decimal places of accuracy just whole centimetres

26. A class decided to study the amount of rainfall in the city of Peterborough for the month of May. The best report would include:

(a) the average rainfall for the month based on measurements taken in the school yard

(b) the average rainfall for the month based on measurements taken at several locations in the city

(c) the daily rainfall for the month based on measurements taken at several locations in the city

(d) the daily rainfall for the month as reported on the local newscast

27. In Olympic swim competitions the timing is now done electronically. This is because:

(a) stop watches aren't accurate

(b) human error in use of the stop watches is eliminated

(c) not enough people can be found to do the timing

(d) new ways of doing things are always better than old ways

28. One half a class found the volume of a block of wood by measuring the length, width and height and calculating, using the formula, $V = L \times W \times H$. The other half of the class found the volume of the same block by using the water displacement method with a graduated cylinder. Examine the data table below.

Volume of Block (measured and calculated)		Volume of Block (water displacement)
60 cm^3		60 cm^3
55 cm^3		50 cm^3
65 cm^3		47 cm^3
59 cm^3		67 cm^3
61 cm^3		70 cm^3
63 cm^3		68 cm^3
57 cm^3		58 cm^3
60 cm^3	Average	60 cm^3

From this data you would conclude that:

(a) both methods of determining volume are equally accurate

(b) water displacement is a more accurate method than measurement and calculation by formula

(c) measurement and calculation by formula is a more accurate method than water displacement

(d) one of the groups worked more carefully than the other group

29. A grade nine class at P.C.V.S. wanted to discover what factors might be involved in determining the height of grade nine students. Which plan would you follow?

(a) measure the height of all the students in the class and record the sex with the height

(b) measure the height of all the students in the class and record the sex and age with the height

(c) measure the height of all the students in all grade nine classes and record the sex and age with the height

(d) measure the height of all the students in all grade nine classes and record the sex, age and colour of eyes with the height

30. A grade seven class at David Fife School wanted to study the amount of traffic on Highway No. 7. The best report would include:

(a) a count of all vehicles travelling from east to west, from 9:00 a.m. to 3:00 p.m. on one day

(b) a count of all vehicles travelling both directions from 9:00 a.m. to 3:00 p.m. on several days

(c) a count of all vehicles travelling from east to west from 9:00 a.m. to 3:00 p.m. on several days

(d) a count of all vehicles in classification groups (transports, motorcycles, cars, etc.) travelling in both directions from 9:00 a.m. to 3:00 p.m. on several days

31. Richard wanted to learn as much as he could about chipmunks during his summer holidays. He should:

(a) catch a chipmunk and watch him in a cage supplied with food and water.

(b) read a book about chipmunks

(c) make notes one day while watching the chipmunks around his cottage

(d) make notes from observations throughout the summer of chipmunks and read reference books about these animals

32. A certain industry was accused of polluting the river water with a waste chemical. To prove whether or not this was happening a scientist would:

(a) take a river water sample near the industry and analyse it

(b) ask the owners of the industry if they were indeed allowing their wastes to escape into the river

(c) take a river water sample near the industry several times throughout one day

(d) take river water samples both above and below the industry one day

(e) take river water samples both above and below the industry at several different times on several different days

33. In order to determine the effect of the amount of fertilizer on the growth of bean seeds, the same number of seeds were planted in three identical trays containing the same type and amount of soil. The amount of water and sunlight was the same for each tray. After three weeks of growth the data was recorded in four ways. Which do you think is the best way?

Tray	Column A	Column B	Column C	Column D
1	-16 of 20 seeds grew -all were tall	-80% of the seeds grew -average height 15 cm	-most of the seeds grew -tallest was 18 cm	-16 of 20 seeds grew -tallest was 18 cm -shortest was 11 cm
2	-15 of 20 seeds grew -most were tall	-75% of the seeds grew -average height 12 cm	-most of the seeds grew -tallest was 17 cm	-15 of 20 seeds grew -tallest was 17 cm -shortest was 11 cm
3	-10 of 20 seeds grew -not as tall as Tray 1 or 2	-50% of the seeds grew -average height 8 cm	-about half the seeds grew -tallest was 11 cm	-10 of 20 seeds grew -tallest was 11 cm -shortest was 4 cm

(a) column A

(b) column B

(c) column C

(d) column D

34. Ingrid flipped a coin five times and got five "heads". From this simple data she could:

(a) conclude that "heads" will come up more often than "tails" for this coin

(b) decide that more trials were needed before concluding anything

(c) conclude that the next five flips will produce "tails" because there is a 50-50 chance for "heads" or "tails"

(d) conclude that the coin is weighted so that only "heads" will appear

35. For a great many years men of science believed that the earth was the centre of our solar system, and that the sun revolved around the earth. They believed this because:

(a) they accepted, without question, what previous men had said

(b) they lacked the precision instruments needed to see and measure the movements of the planets

(c) they did not use the scientific method for investigating a problem

(d) all of the above

36. Todd had read in a newspaper article that someone had claimed that praying over plants improved their growth rate. He decided to grow two bean plants from seed, praying over one and not over the other. The one Todd prayed over after one month was 5 cm taller than the other plant. Todd should conclude that:

(a) praying over plants increases their rate of growth

(b) many more trials are needed, which include controls for such things as the warmth or moisture from his breath, before he accepts the statement made in the newspaper

(c) the taller plant received more water or sunlight

(d) his breath, while praying over the plant, somehow caused the plant to grow taller

37. The school track coach wanted to pick girls and boys for the track team. He should:

(a) watch the girls and boys during recess activities then pick his team

(b) pick the older girls and boys

(c) use a stop watch for time trials in a 100 m sprint

(d) measure the trials of all competitors for all the events scheduled

38. At some soccer and hockey camps report cards are made out for each boy or girl. If these reports are done by an instructor watching a final scrimmage they are:

(a) probably not reliable because the instructor can watch one player for only a few minutes

(b) probably accurate because the instructor is very good at the skills of the game

(c) probably accurate because all the skills can be observed in a game

(d) probably accurate because a student who is weak or strong in one skill of the game is probably weak or strong in all of the skills

39. Joan is trying to decide which weed killer she should buy. She decides to buy two brands and carry out an experiment to see which is more effective. In a small section of her lawn she sprays brand "X" on fifty dandelions and brand "Y" on fifty crab grass plants. After one week she records her data.

Brand "X"	Brand "Y"
1. 40/50 dandelions were dying or dead	1. 35/50 crab grass plants were dying or dead
2. 80% effective	2. 70% effective

From this data Joan should conclude that:

(a) brand "X" is the better weed killer

(b) brand "X" should be used on more dandelions and brand "Y" on more crab grass because it's hard to tell which is better

(c) the experiment should be repeated using brand "X" on the crab grass and brand "Y" on the dandelions

(d) the experiment would give more meaningful results if she tried both weed killers on a greater variety of weeds

40. Mary had just learned that the mass value of 1 mL of a liquid varied from liquid to liquid. By using a balance to measure mass and a graduated cylinder to measure volume, Mary obtained the following data.

Mass of Gasoline	Volume of Gasoline	Mass/Volume
6.4 g	10.0 mL	0.64 g/mL

When Mary checked in her text book the value given for gasoline was 0.68 g/mL. Mary should:

(a) conclude that her balance wasn't working properly

(b) conclude that the text book has printed an error

(c) conclude that her volume measurement was not read correctly

(d) make no conclusions at this time

41. Mary had just learned that the mass value of 1 mL of a liquid varied from liquid to liquid. By using a balance to measure mass and a graduated cylinder to measure volume, Mary obtained the following data.

Mass of Gasoline	Volume of Gasoline	Mass/Volume
6.4 g	10.0 mL	0.64 g/mL

When Mary checked in her text book the value given for gasoline was 0.68 g/mL. Mary decided to repeat her experiment five more times and asked Joe if he would do the same experiment with his equipment. Mary's and Joe's data is given below.

		Mass of Gasoline	Volume of Gasoline	Mass/Volume
Mary	1.	6.3 g	10.0 mL	0.63 g/mL
	2.	6.5 g	10.0 mL	0.65 g/mL
	3.	6.5 g	10.0 mL	0.65 g/mL
	4.	6.4 g	10.0 mL	0.64 g/mL
	5.	6.4 g	10.0 mL	0.64 g/mL
Joe	1.	6.5 g	10.0 mL	0.65 g/mL
	2.	6.4 g	10.0 mL	0.64 g/mL
	3.	6.4 g	10.0 mL	0.64 g/mL
	4.	6.5 g	10.0 mL	0.65 g/mL
	5.	6.4 g	10.0 mL	0.64 g/mL
Average		6.4 g	10.0 mL	0.64 g/mL

Mary should:

(a) conclude that the text book definitely has printed an error

(b) conclude that both her and Joe's balance are not working properly

(c) make no conclusions at this time

(d) conclude that some other variable, such as type of gasoline, may be at work here

42. Allison was trying to decide whether or not a particular insect which was abundant in her garden could be classified in the same group as grasshoppers. Before making a decision she should:

(a) examine one of these insects very carefully comparing its structure to that of the grasshopper

(b) examine many of these insects very carefully comparing their structure to that of the grasshopper

(c) set up an escape proof terrarium and observe the structure and changes that occur with several specimens over a period of time

(d) look for pictures of the insect in a reference book, discover its name, then check in a classification book to see if the name appears in the grasshopper group

43. A grade eight class wished to compare several brands of canned mixed nuts. The best data table would contain:

(a) mass values for each of the different kinds of nuts, both whole and pieces, for each brand

(b) a count of the total number of nuts found in each can

(c) a count of the number of each kind of nut in each can

(d) mass values for the entire contents of each can

44. Hal wanted to find the volume of one small glass marble. He decided to find the volume of 20 similar marbles using a graduated cylinder and the water displacement technique then dividing by 20. Below are Hal's results.

Number of Marbles	Starting Level of Water in Cylinder	Final Level of Water in Cylinder
20	25 mL	65 mL

Hal concluded that the volume of 1 marble was 0.2 g. Do you think:

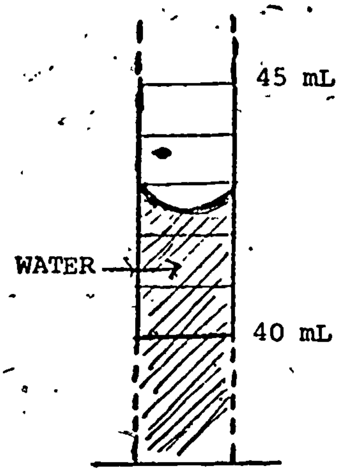
(a) Hal has enough data to find the correct volume of 1 marble

(b) Hal does not have enough data to find the correct volume of 1 marble

(c) Hal has not used his data correctly to find the volume of 1 marble

(d) Hal could have simplified his experiment by placing just 1 marble in the graduated cylinder and reading the increase in volume

45. Examine the diagram of the graduated cylinder



The correct reading of the level of the water in the graduated cylinder is:

(a) 43.5 mL

(b) 43.0 mL

(c) 42.5 mL

(d) somewhere between 40 and 45 mL

46. When reading a scale in order to obtain a measurement value you usually:

(a) read to the nearest mark on the scale

(b) estimate 1/2 or 1/4 of the way between the marks on the scale depending on how far apart the marks are

(c) read to the nearest printed number on the scale

(d) always round off to whole numbers

47. Bob believes that adding fertilizer to a plant makes it grow taller. He does an experiment to prove this but the results turn out to be somewhat different from what he expected. What should he do next?

(a) change his opinion about fertilizer helping plants to grow

(b) repeat the experiment and accept the results if they show what he expects

(c) decide that something had gone wrong with the experiment and continue believing that fertilizer helps plants to grow

(d) repeat the experiment several times and base his opinion on the average results

(e) repeat the experiment several times and check his results with some research material regarding this topic before forming his opinion

48. Shirley had these three measurements of volume to enter on a data sheet: 73.482 m^3, 4.7 m^3, 238.467 m^3. Which column would be the best way of entering this data?

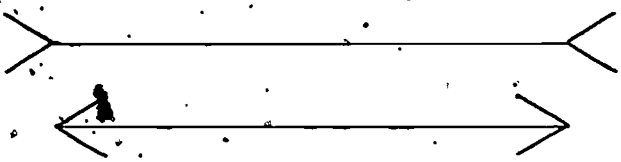
Column A	Column B	Column C
73.487 m^3	73.5 m^3	73.49 m^3
4.7 m^3	4.7 m^3	4.70 m^3
238.462 m^3	238.5 m^3	238.46 m^3

(a) column A is the best way of expressing these numerals

(b) column B is the best way of expressing these numerals

(c) column C is the best way of expressing these numerals

(d) anyone of these columns is as good as the other

49. 

These two parallel lines were given by a math teacher for the students to talk about. They were asked to state how they thought the lengths of these parallel lines compared. Which would be the best way to make the comparison of length?

(a) by inspection of the parallel lines

(b) measure and compare the lengths of the lines in cm

(c) measure and compare the lengths of the lines in mm

(d) by using your pencil to compare their lengths

50. When measuring the volume of a cube, the most accurate answer would be obtained by:

(a) measuring the length of the sides and using the mathematical formula V = L x W x H .

(b) placing the cube in a narrow graduated cylinder and measuring the amount that the water rises

(c) placing the cube in a wide graduated cylinder and measuring the amount that the water rises

(d) placing the cube in a beaker that is filled to the brim with water and measuring the amount of water that overflows

51. Listed below are 3 sets of descriptions corresponding to the necessary information listed at the left. These are attempts at accurately describing a particular insect.

	Column A	Column B	Column C
Size	long	5 cm	length of my rubber
Shape	long and roundish	egg shaped	balloon shaped
Colour	red and white polka-dots	reddish-orange with white spots	like a red spotted leopard
Texture	rough	covered with short prickly spines	like a ragged saw blade
Mass	light	2.5 grams	feather weight
Attachments	wings and legs	2 sets of wings 3 sets of legs	similar to any insect
Special Features	many hairs on front of head	2 sets of antenna on head	cat like whiskers on head

Which column gives the best scientific description of the insect? Circle the letter of the correct answer.

(a) column A

(b) column B

(c) column C

(d) either column is adequate

52. Paul wanted to see if there was a relationship between the volumes of figures (cube, rectangular solid, cylinder) when the dimensions were doubled. He used the following data:

	Dimensions	Volume	Doubled Dimensions	New Volume
Cube	2.0 x 2.0 x 2.0	8 cm^3	4.0 x 4.0 x 4.0	64 cm^3
Rectangular Solid	1.0 x 2.0 x 3.0	6 cm^3	2.0 x 4.0 x 6.0	48 cm^3
Cylinder	Radius 2.0 Height 3.0	38 cm^3	Radius 4.0 Height 6.0	300 cm^3

Paul found that when the dimensions were doubled the new volume was 8 times the original volume. What is the best consideration before stating his conclusions:
Circle the letter of the best answer.

(a) Consider his data as correct and write his concluding statement of relationships.

(b) Check all his figures before writing his concluding statement.

(c) Test his findings by using another set of dimensions.

(d) Use many more sets of dimensions before writing his concluding statement.

53. Lisa wanted to see if there was a relationship between the areas of figures (square, rectangle, triangle) when the dimensions were doubled. She used the following data:

	Dimensions	Area (cm^2)	Doubled Dimensions	New Area (cm^2)
Square	2.0 cm x 2.0 cm	4.0	4.0 cm x 4.0 cm	16
Rectangle	3.0 cm x 4.0 cm	12.0	6.0 cm x 8.0 cm	48
Triangle	4.0 cm x 5.0 cm	10.0	8.0 cm x 10.0 cm	40

Lisa found that when the dimensions were doubled the new area was 4 times that of the original. What would be her best consideration before writing her conclusions?
Circle the letter of the best answer.

(a) Test her findings with many more sets of dimensions before writing a concluding statement.

(b) Accept her findings as correct and write her concluding statement.

(c) Check all her figures and calculations for accuracy before writing her conclusion.

(d) Test her findings by using another set of dimensions before writing her concluding statement.

54. Stan and Scott chose to study a colony of Great Blue Herons that were nesting on Rice Lake. After one day of observations they had accumulated a number of pages of notes. Before reporting their findings to the class they should do one of the following:

Circle the letter of the best statement.

(a) They should check their observation notes over carefully before writing their report.

(b) They should invite some other students to witness their observations.

(c) They should observe the colony many more times before writing their report of their findings

(d) They should observe the colony one more day before writing their final report.

(e) They should accept their observations as adequate and write their final report.

55. One day in the 1600's, Jean-Baptiste van Helmont, a Belgian physician, wrote a recipe for producing mice. He said it could be done in 21 days by putting a dirty shirt and some grains of wheat in a pot or box, and setting this away in a dark place where it would not be disturbed. He believed that the active principle in producing the mice was the human perspiration in the shirt. He tried out his recipe many times, and got mice every time.

There is obviously something wrong with this recipe for producing mice. What has this physician not done with his experiment to prove his recipe. Circle the letter of the statement that you think is the best procedure to follow.

(a) Use the recipe with a clean shirt.

(b) Have other people try the recipe.

(c) Keep the shirt in a mouse-proof container.

(d) Check his results more accurately.

(e) Try his recipe with other clothing.

56. Students in Mr. Green's Science class were each given a piece of paper. Each student was asked to make a list of the things he or she would want to make notes about or comment about when describing some objects that Mr. Green was going to show them. Before the students observe the objects each student should make sure his or her list is as adequate as possible. Circle the letter of the best suggestion.

(a) Each student should check his or her list with a neighbour's list for completeness.

(b) Each student should re-examine and check his or her list for completeness.

(c) Students should make a master list from all the student's suggestions in the class.

(d) Students should get together in groups to compile complete lists.

57. Four separate groups of students were trying to find the volume of an irregularly shaped solid by displacing water from a large beaker. The overflow of water was collected in a graduated cylinder.

Which one of the statements below describes the way to ensure the most accurate result?
Circle the letter of the best suggestion.

(a) Each group should repeat the experiment a number of times as carefully as possible.

(b) Each group could accept their first result if it had been done carefully.

(c) Each group could repeat the experiment a number of times and average its results.

(d) The groups could average the results of a single trial for the final answer.

(e) Each group could do the experiment a number of times and average all the results from all the groups together.

D. RECORDING INFORMATION - Intermediate

Answer Sheet - Version 1

1. Radiation and Heat Absorption (c)
2. Heat Conduction (b)
3. Pendulum (d)
4. Thermal Expansion (a)
5. Goldfish (e)

Answer Sheet - Version 2

	Items 1	2	3	4
1. Radiation and Heat Absorption	(iii)	(i)	(iii)	(i)
2. Heat Conduction	(iii)	(iii)	(ii)	(i)
3. Pendulum	(ii)	(iii)	(iii)	(ii)
4. Thermal Expansion	(i)	(iii)	(i)	(iii)
5. Goldfish	(iii)	(i)	(iii)	(iii)

Note: Students must select the correct answer for all 4 questions to score correct on the item.

Answer Sheet - Version 3

1. Radiation and Heat Absorption — See option (c), version 1
2. Heat Conduction — See option (b), version 1
3. Pendulum — See option (d), version 1
4. Thermal Expansion — See option (a), version 1
5. Goldfish — See option (e), version 1

1. Radiation and Heat Absorption
   (Version 1)

Jim and his father went to buy an aluminum tool shed on a hot day. They liked two models but Jim noticed one was much warmer inside than the other. The two were of different colours, also one was shiny and one dull. He decided to try and find out if colour and the lustre of the finish could affect the temperature inside the sheds.

He used 6 empty juice cans with the labels removed to represent the tool sheds and a big light bulb to represent the sun. He painted two cans black, 2 green and 2 white. He used shiny enamel paint for one of the cans of each colour, and a dull flat paint for the other can of each colour. Taking each can in turn, he put a thermometer inside it, turned it upside down and placed it near the lamp. After 10 minutes he read the temperature inside the can. He is a careful worker so after the cans had cooled off he did this a second time with each one, and then a third time.

Here are the notes he kept.

Colour	Lustre	Interior Colour of Can	Trial	Size of Lamp	Distance of Lamp	Time of Exposure	Size of Can	Temp. of Room	Temp. inside can after exposure	Temp. change in °C
black	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	26.9°C	6.9
black	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	26.7°C	6.7
black	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	26.7°C	6.7
black	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	30.0°C	10.0
black	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	29.8°C	9.8
black	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	30.1°C	10.1
white	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	23.2°C	3.2
white	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	23.3°C	3.3
white	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	23.2°C	3.2
white	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	24.8°C	4.8
white	dull	silver	2	250 W	20 cm	10 min.	1 L	20°C	24.7°C	4.7
white	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	24.7°C	4.7
green	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	26.1°C	6.1
green	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	25.9°C	5.9
green	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	26.0°C	6.0
green	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	28.7°C	8.7
green	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	28.8°C	8.8
green	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	28.7°C	8.7

This was Jim's question: "Do colour and degree of shininess together determine the absorption of heat through aluminum?"

Directions: Which of these charts best organizes the information he needs to answer his question?

Circle the letter of the correct answer.

(a) Temperature in °C inside can after exposure

Colour	Shiny Trial 1	Trial 2	Trial 3	Dull Trial 1	Trial 2	Trial 3	Size of Lamp
black	26.9	26.7	26.7	30.0	29.8	30.1	250 W
white	23.2	23.3	23.2	24.8	24.7	24.7	250 W
green	26.1	25.9	26.0	28.7	28.8	28.7	250 W

(b) Temperature in °C inside can after exposure

Colour	Shiny Trial 1	Dull Trial 1
black	26.9	30.0
white	23.2	24.8
green	26.1	28.7

(c) Temperature in °C inside can after exposure

Colour	Shiny Trial 1	Trial 2	Trial 3	Dull Trial 1	Trial 2	Trial 3
black	26.9	26.7	26.7	30.0	29.8	30.1
white	23.2	23.3	23.2	24.8	24.7	24.7
green	26.1	25.9	26.0	28.7	28.8	28.7

(d) Temperature in °C inside can after exposure

Colour	Shiny Trial 1	Trial 2	Trial 3	Dull Trial 1	Trial 2	Trial 3
white	23.2	23.3	23.2	24.8	24.7	24.7

(e)

Colour of Can	Size of Lamp Dull	Shiny
black	250 W	250 W
white	250 W	250 W
green	250 W	250 W

1. Radiation and Heat Absorption
(Version 2)

Jim and his father went to buy an aluminum tool shed on a hot day. They liked two models but Jim noticed one was much warmer inside than the other. The two were of different colours, also one was shiny and one dull. He decided to try and find out if colour and the lustre of the finish could affect the temperature inside the sheds.

He used 6 empty juice cans with the labels removed to represent the tool sheds and a big light bulb to represent the sun. He painted two cans black, 2 green and 2 white. He used shiny enamel paint for one of the cans of each colour, and a dull flat paint for the other can of each colour. Taking each can in turn, he put a thermometer inside it, turned it upside down and placed it near the lamp. After 10 minutes he read the temperature inside the can. He is a careful worker so after the cans had cooled off he did this a second time with each one, and then a third time.

Here are the notes he kept.

Colour	Lustre	Interior Colour of Can	Trial	Size of Lamp	Distance of Lamp	Time of Exposure	Size of Can	Temp. of Room	Temp. inside can after exposure	Temp. change in °C
black	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	26.9°C	6.9
black	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	26.7°C	6.7
black	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	26.7°C	6.7
black	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	30.0°C	10.0
black	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	29.8°C	9.8
black	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	30.1°C	10.1
white	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	23.2°C	3.2
white	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	23.3°C	3.3
white	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	23.2°C	3.2
white	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	24.8°C	4.8
white	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	24.7°C	4.7
white	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	24.7°C	4.7
green	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	26.1°C	6.1
green	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	25.9°C	5.9
green	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	26.0°C	6.0
green	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	28.7°C	8.7
green	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	28.8°C	8.8
green	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	28.7°C	8.7

This was Jim's question: "Do colour and degree of shininess together determine the absorption of heat through aluminum?"

He made up this chart to organize the information he needed to answer it.

	Temperature in °C inside can after exposure					
	Shiny			Dull		
Colour	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
black (s)	(a)	(b)	(c)	(d)	(e)	(f)
white (t)	(g)	(h)	(i)	(j)	(k)	(l)
green (u)	(m)	(n)	(o)	(p)	(q)	(r)

1. How should he record the information that the lamp was 250 W?

   Circle the number of the correct answer.

   (i) Put 250 W in spaces (a) to (r).

   (ii) Put 250 W in spaces (s), (t) and (u).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

2. How should he record the fact that the temperature reached 26.9°C in the shiny black can on the 1st trial?

   Circle the number of the correct answer.

   (i) Put 26.9°C in space (a).

   (ii) Put 26.9°C in space (d).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

3. How should he record the fact that the temperature changed 4.8°C in the dull white can on the 1st trial?

   Circle the number of the correct answer.

   (i) Put 4.8°C in space (j).

   (ii) Put 4.8°C in space (l).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

4. How should he record the temperatures reached in the shiny green can?

   Circle the number of the correct answer.

   (i) Put 26.1°C, 25.9°C and 26.0°C in spaces (m), (n) and (o).

   (ii) Put 28.7°C, 28.8°C and 28.7°C in spaces (m), (n) and (o).

   (iii) Leave them out.

   (iv) Make up new spaces for the information.

1. Radiation and Heat Absorption (Version 3)

Jim and his father went to buy an aluminum tool shed on a hot day. They liked two models but Jim noticed one was much warmer inside than the other. The two were of different colours, also one was shiny and one dull. He decided to try and find out if colour and the lustre of the finish could affect the temperature inside the sheds.

He used 6 empty juice cans with the labels removed to represent the tool sheds and a big light bulb to represent the sun. He painted two cans black, 2 green and 2 white. He used shiny enamel paint for one of the cans of each colour, and a dull flat paint for the other can of each colour. Taking each can in turn, he put a thermometer inside it, turned it upside down and placed it near the lamp. After 10 minutes he read the temperature inside the can. He is a careful worker so after the cans had cooled off he did this a second time with each one, and then a third time.

Here are the notes he kept.

Colour	Lustre	Interior Colour of Can	Trial	Size of Lamp	Distance of Lamp	Time of Exposure	Size of Can	Temp. of Room	Temp. inside can after exposure	Temp. change in °C
black	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	26.9°C	6.9
black	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	26.7°C	6.7
black	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	26.7°C	6.7
black	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	30.0°C	10.0
black	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	29.8°C	9.8
black	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	30.1°C	10.1
white	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	23.2°C	3.2
white	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	23.3°C	3.3
white	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	23.2°C	3.2
white	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	24.8°C	4.8
white	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	24.7°C	4.7
white	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	24.7°C	4.7
green	shiny	silver	1	250 W	20 cm	10 min	1 L	20°C	26.1°C	6.1
green	shiny	silver	2	250 W	20 cm	10 min	1 L	20°C	25.9°C	5.9
green	shiny	silver	3	250 W	20 cm	10 min	1 L	20°C	26.0°C	6.0
green	dull	silver	1	250 W	20 cm	10 min	1 L	20°C	28.7°C	8.7
green	dull	silver	2	250 W	20 cm	10 min	1 L	20°C	28.8°C	8.8
green	dull	silver	3	250 W	20 cm	10 min	1 L	20°C	28.7°C	8.7

This was Jim's question: "Do colour and degree of shininess together determine the absorption of heat through aluminum?"

Directions: Use the information to fill in this chart so he can answer his question.

Add more rows or columns if you need them.

Temperature in °C inside can after exposure

Colour	Shiny Trial 1	Trial 2	Trial 3	Dull Trial 1	Trial 2	Trial 3
black						
white						
green						

2. Heat Conduction
(Version 1)

Suppose you wanted to find out whether heat was conducted better through one kind of cooking pot than another. You found 4 flat-bottomed pots, two of aluminum and two of copper. Two of the pots, one of each metal, were 2 mm thick on the bottom and the other 2 were just 1 mm thick. You had four hotplates with equal burners. You filled each pot with the same amount and temperature of water and placed each on one of the burners. You put a floating thermometer in each pot. Then you turned on all the burners at the same time and watched them carefully, measuring the time it took the water to reach 100°C. You did all this three times, using fresh water in the pots each time and waiting between trials for the burners to cool down.

Here is the information you collected.

Metal of Pot	Thickness of bottom	Diameter of pot	Temperature of water at beginning	Amount of Water	Trial	Time between trials	Time to reach 100°C
aluminum	1 mm	12 cm	10°C	1 L	1	0	6 min 5 s
aluminum	1 mm	12 cm	10°C	1 L	2	5 min	5 min 59 s
aluminum	1 mm	12 cm	10°C	1 L	3	5 min	5 min 40 s
aluminum	2 mm	12 cm	10°C	1 L	1	0	8 min 6 s
aluminum	2 mm	12 cm	10°C	1 L	2	5 min	7 min 53 s
aluminum	2 mm	12 cm	10°C	1 L	3	5 min	7 min 48 s
copper	1 mm	12 cm	10°C	1 L	1	0	5 min 2 s
copper	1 mm	12 cm	10°C	1 L	2	5 min	4 min 56 s
copper	1 mm	12 cm	10°C	1 L	3	5 min	4 min 30 s
copper	2 mm	12 cm	10°C	1 L	1	0	7 min 6 s
copper	2 mm	12 cm	10°C	1 L	2	5 min	6 min 50 s
copper	2 mm	12 cm	10°C	1 L	3	5 min	6 min 30 s

Your question is: Do metal type or thickness together determine heat conduction?

Directions: Which of these charts best organizes the information you need to answer your question?

Circle the letter of the best answer.

(a) Time to Reach 100°C

	Thickness	
Metal of Pot	1 mm	2 mm
aluminum	6 min 5 s	8 min 6 s
copper	5 min 2 s	7 min 6 s

Time To Reach 100°C

Thickness

Metal of Pot	1 mm Trial 1	Trial 2	Trial 3	2 mm Trial 1	Trial 2	Trial 3
aluminum	6 min 5 s	5 min 59 s	5 min 40 s	8 min 6 s	7 min 53 s	7 min 48 s
copper	5 min 2 s	4 min 56 s	4 min 30 s	7 min 6 s	6 min 50 s	6 min 30 s

(c)

Time to Reach 100°C

Thickness

Metal of Pot	1 mm Trial 1	Trial 2	Trial 3	2 mm Trial 1	Trial 2	Trial 3
aluminum	6 min 5 s	5 min 59 s	5 min 40 s	8 min 6 s	7 min 53 s	7 min 48 s

(d)

Time Between Trials

Thickness

Metal of Pot	1 mm Trial 1	Trial 2	Trial 3	2 mm Trial 1	Trial 2	Trial 3
aluminum	0	5 min	5 min	0	5 min	5 min
copper	0	5 min	5 min	0	5 min	5 min

(e)

Time To Reach 100°C — Thickness / Time Between Trials — Thickness

Metal of Pot	Time To Reach 100°C, 1 mm Trial 1	Trial 2	Trial 3	2 mm Trial 1	Trial 2	Trial 3	Time Between Trials, 1 mm Trial 1	Trial 2	Trial 3	2 mm Trial 1	Trial 2	Trial 3
um	6 min 5 s	5 min 59 s	5 min 40 s	8 min 6 s	7 min 53 s	7 min 48 s	0	5 min	5 min	0	5 min	5 mi
copper	5 min 2 s	4 min 56 s	4 min 30 s	7 min 6 s	6 min 50 s	6 min 30 s	0	5 min	5 min	0	5 min	5 mi

2. Heat Conduction
(Version 2)

Suppose you wanted to find out whether heat was conducted better through one kind of cooking pot than another. You found 4 flat-bottomed pots, two of aluminum and two of copper. Two of the pots, one of each metal, were 2 mm thick on the bottom and the other 2 were just 1 mm thick. You had four hotplates with equal burners. You filled each pot with the same amount and temperature of water and placed each on one of the burners. You put a floating thermometer in each pot. Then you turned on all the burners at the same time and watched them carefully, measuring the time it took the water to reach 100°C. You did all this three times, using fresh water in the pots each time and waiting between trials for the burners to cool down.

Here is the information you collected.

Metal of Pot	Thickness of bottom	Diameter of pot	Temperature of water at beginning	Amount of Water	Trial	Time between trials	Time to reach 100°C
aluminum	1 mm	12 cm	10°C	1 L	1	0	6 min 5 s
aluminum	1 mm	12 cm	10°C	1 L	2	5 min	5 min 59 s
aluminum	1 mm	12 cm	10°C	1 L	3	5 min	5 min 40 s
aluminum	2 mm	12 cm	10°C	1 L	1	0	8 min 6 s
aluminum	2 mm	12 cm	10°C	1 L	2	5 min	7 min 53 s
aluminum	2 mm	12 cm	10°C	1 L	3	5 min	7 min 48 s
copper	1 mm	12 cm	10°C	1 L	1	0	5 min 2 s
copper	1 mm	12 cm	10°C	1 L	2	5 min	4 min 56 s
copper	1 mm	12 cm	10°C	1 L	3	5 min	4 min 30 s
copper	2 mm	12 cm	10°C	1 L	1	0	7 min 6 s
copper	2 mm	12 cm	10°C	1 L	2	5 min	6 min 50 s
copper	2 mm	12 cm	10°C	1 L	3	5 min	6 min 30 s

Your question is: "Do metal type or thickness together determine heat conduction?"

You made up this chart to organize the information you need to answer it.

Time To Reach 100°C

Thickness

Metal of Pot	1 mm Trial 1	Trial 2	Trial 3	2 mm Trial 1	Trial 2	Trial 3
aluminum (m)	(a)	(b)	(c)	(g)	(h)	(i)
copper (n)	(d)	(e)	(f)	(j)	(k)	(l)

1. How should you record the information that the water was 10°C at the beginning of the 1st trial in the 1 mm thick aluminum pot?

   Circle the number of the correct answer.

   (i) Put 10°C in space (a).

   (ii) Put 10°C in spaces (a) to (l).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

2. How should you record the times between trials for the 2 mm thick copper pot?

   Circle the number of the correct answer.

   (i) Put 0, 5 min and 5 min in spaces (j), (k) and (l).

   (ii) Put 0, 5 min and 5 min in spaces (d), (e) and (f) and also in spaces (j), (k) and (l).

   (iii) Leave them out.

   (iv) Make up new spaces for the information.

3. How should you record the information that on the 3rd trial the 2 mm thick copper pot took 6 min 30 s to reach 100°C?

   Circle the number of the correct answer.

   (i) Put 6 min 30 s in space (j).

   (ii) Put 6 min 30 s in space (l).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

4. How should you record the times taken to reach 100°C by the 1 mm thick aluminum pot?

   Circle the number of the correct answer.

   (i) Put the times taken in spaces (a), (b) and (c).

   (ii) Put the times taken in spaces (d), (e) and (f).

   (iii) Leave them out.

   (iv) Make up new spaces for the information.

2. Heat Conduction
(Version 3)

Suppose you wanted to find out whether heat was conducted better through one kind of cooking pot than another. You found 4 flat-bottomed pots, two of aluminum and two of copper. Two of the pots, one of each metal, were 2 mm thick on the bottom and the other 2 were just 1 mm thick. You had four hotplates with equal burners. You filled each pot with the same amount and temperature of water and placed each on one of the burners. You put a floating thermometer in each pot. Then you turned on all the burners at the same time and watched them carefully, measuring the time it took the water to reach 100°C. You did all this three times, using fresh water in the pots each time and waiting between trials for the burners to cool down.

Here is the information you collected.

Metal of Pot	Thickness of bottom	Diameter of pot	Temperature of water at beginning	Amount of Water	Trial	Time between trials	Time to reach 100°C
aluminum	1 mm	12 cm	10°C	1 L	1	0	6 min 5 s
aluminum	1 mm	12 cm	10°C	1 L	2	5 min	5 min 59 s
aluminum	1 mm	12 cm	10°C	1 L	3	5 min	5 min 40 s
aluminum	2 mm	12 cm	10°C	1 L	1	0	8 min 6 s
aluminum	2 mm	12 cm	10°C	1 L	2	5 min	7 min 53 s
aluminum	2 mm	12 cm	10°C	1 L	3	5 min	7 min 48 s
copper	1 mm	12 cm	10°C	1 L	1	0	5 min 2 s
copper	1 mm	12 cm	10°C	1 L	2	5 min	4 min 56 s
copper	1 mm	12 cm	10°C	1 L	3	5 min	4 min 30 s
copper	2 mm	12 cm	10°C	1 L	1	0	7 min 6 s
copper	2 mm	12 cm	10°C	1 L	2	5 min	6 min 50 s
copper	2 mm	12 cm	10°C	1 L	3	5 min	6 min 30 s

Your question is: "Do metal type or thickness together determine heat conduction?"

Directions: Use the information to fill in this chart so you can answer your question.

Add more rows or columns if you need them.

Time to Reach 100°C

Thickness

Metal of Pot	1 mm Trial 1	Trial 2	2 mm Trial 3	Trial 1	Trial 2	Trial 3
aluminum						
copper						

3. Pendulum
(Version 1)

To study how a grandfather clock works the class made a pendulum. They used a string, attached to the edge of a table, for an arm and attached a weight for a bob. They selected 2 different strings of 10 cm and 30 cm in length and 3 different masses of bob (1 g, 5 g and 10 g). They measured the period (the time it takes for the pendulum to move through its arc) for each arm length and mass combination. They made 3 measurements for each. Everything else, such as starting the swing from the same point, was kept the same for each test.

Here is the information they collected.

Length of arm	Mass of bob	Trial	Period in seconds	Height of bob from floor at beginning of swing	Metal of bob	Shape of bob
10 cm	1 g	1	.6	1 m	aluminum	round
10 cm	1 g	2	.7	1 m	aluminum	round
10 cm	1 g	3	.6	1 m	aluminum	round
10 cm	5 g	1	.6	1 m	copper	round
10 cm	5 g	2	.6	1 m	copper	round
10 cm	5 g	3	.6	1 m	copper	round
10 cm	10 g	1	.7	1 m	iron	round
10 cm	10 g	2	.7	1 m	iron	round
10 cm	10 g	3	.6	1 m	iron	round
30 cm	1 g	1	1.6	1 m	aluminum	round
30 cm	1 g	2	1.5	1 m	aluminum	round
30 cm	1 g	3	1.6	1 m	aluminum	round
30 cm	5 g	1	1.5	1 m	copper	round
30 cm	5 g	2	1.5	1 m	copper	round
30 cm	5 g	3	1.6	1 m	copper	round
30 cm	10 g	1	1.6	1 m	iron	round
30 cm	10 g	2	1.6	1 m	iron	round
30 cm	10 g	3	1.5	1 m	iron	round

Their question is: "Do arm length and mass of the bob together determine the period of a pendulum?"

Directions: Which of these charts best organizes the information you need to answer your question.

Circle the letter of the correct answer.

(a)

	Period in Seconds	
	Length of Arm	
Mass of Bob	10 cm	30 cm
1 g	.6	1.6
5 g	.6	1.5
10 g	.7	1.6

(b)

	Period in Seconds					
	Length of Arm					
	10 cm			30 cm		
Mass of Bob	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
5 g	.6	.6	.6	1.5	1.5	1.6

(c)

Mass of Bob	Metal of Bob
1 g	aluminum
5 g	copper
10 g	iron

(d)

	Period in Seconds					
	Length of Arm					
	10 cm			30 cm		
Mass of Bob	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1 g	.6	.7	.6	1.6	1.5	1.6
5 g	.6	.6	.6	1.5	1.5	1.6
10 g	.7	.7	.6	1.6	1.6	1.5

(e)

	Period in Seconds						
	Length of Arm						
	10 cm			30 cm			
Mass of Bob	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Metal of Bob
1 g	.6	.7	.6	1.6	1.5	1.6	aluminum
5 g	.6	.6	.6	1.5	1.5	1.6	copper
10 g	.7	.7	.6	1.6	1.6	1.5	iron

3. Pendulum
(Version 2)

To study how a grandfather clock works the class made a pendulum. They used a string, attached to the edge of a table, for an arm and attached a weight for a bob. They selected 2 different strings of 10 cm and 30 cm in length and 3 different masses of bob (1 g, 5 g and 10 g). They measured the period (the time it takes for the pendulum to move through its arc) for each arm-length and mass combination. They made 3 measurements for each. Everything else, such as starting the swing from the same point, was kept the same for each test.

Here is the information they collected.

Length of arm	Mass of bob	Trial	Period in seconds	Height of bob from floor at beginning of swing	Metal of bob	Shape of bob
10 cm	1 g	1	.6	1 m	aluminum	round
10 cm	1 g	2	.7	1 m	aluminum	round
10 cm	1 g	3	.6	1 m	aluminum	round
10 cm	5 g	1	.6	1 m	copper	round
10 cm	5 g	2	.6	1 m	copper	round
10 cm	5 g	3	.6	1 m	copper	round
10 cm	10 g	1	.7	1 m	iron	round
10 cm	10 g	2	.7	1 m	iron	round
10 cm	10 g	3	.6	1 m	iron	round
30 cm	1 g	1	1.6	1 m	aluminum	round
30 cm	1 g	2	1.5	1 m	aluminum	round
30 cm	1 g	3	1.6	1 m	aluminum	round
30 cm	5 g	1	1.5	1 m	copper	round
30 cm	5 g	2	1.5	1 m	copper	round
30 cm	5 g	3	1.6	1 m	copper	round
30 cm	10 g	1	1.6	1 m	iron	round
30 cm	10 g	2	1.6	1 m	iron	round
30 cm	10 g	3	1.5	1 m	iron	round

Their question is: "Do arm length and mass of the bob together determine the period of the pendulum?"

They made up this chart to organize the information they needed to answer it.

	Period in Seconds					
	Length of Arm					
	10 cm			30 cm		
Mass of bob	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1 g (s)	(a)	(b)	(c)	(d)	(e)	(f)
5 g (t)	(g)	(h)	(i)	(j)	(k)	(l)
10 g (u)	(m)	(n)	(o)	(p)	(q)	(r)

1. How should they record the periods of the 30 cm arm with a 10 g bob?

   Circle the number of the correct answer.

   (i) Put the periods in spaces (j), (k) and (l).

   (ii) Put the periods in spaces (p), (q) and (r).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

2. How should they record the information about the metal of the bobs?

   Circle the number of the correct answer.

   (i) Put this information in spaces (s), (t) and (u).

   (ii) Put this information in spaces (a) to (r).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

3. How should they record the fact that the height of the bob at the beginning of the swing was always 1 m?

   Circle the number of the correct answer.

   (i) Put 1 m in each of the spaces (s), (t) and (u).

   (ii) Put 1 m in each of the spaces (a) to (r).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

4. How should they record the fact that the 3rd trial period of the 5 g bob on a 10 cm arm was .6 seconds?

   Circle the number of the correct answer.

   (i) Put .6 seconds in space (c).

   (ii) Put .6 seconds in space (i).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

3. Pendulum
(Version 3)

To study how a grandfather clock works the class made a pendulum. They used a string, attached to the edge of a table, for an arm and attached a weight for a bob. They selected 2 different strings of 10 cm and 30 cm in length and 3 different masses of bob (1 g, 5 g and 10 g). They measured the period (the time it takes for the pendulum to move through its arc) for each arm length and mass combination. They made 3 measurements for each. Everything else, such as starting the swing from the same point, was kept the same for each test.

Here is the information they collected.

Length of arm	Mass of bob	Trial	Period in seconds	Height of bob from floor at beginning of swing	Metal of bob	Shape of bob
10 cm	1 g	1	.6	1 m	aluminum	round
10 cm	1 g	2	.7	1 m	aluminum	round
10 cm	1 g	3	.6	1 m	aluminum	round
10 cm	5 g	1	.6	1 m	copper	round
10 cm	5 g	2	.6	1 m	copper	round
10 cm	5 g	3	.6	1 m	copper	round
10 cm	10 g	1	.7	1 m	iron	round
10 cm	10 g	2	.7	1 m	iron	round
10 cm	10 g	3	.6	1 m	iron	round
30 cm	1 g	1	1.6	1 m	aluminum	round
30 cm	1 g	2	1.5	1 m	aluminum	round
30 cm	1 g	3	1.6	1 m	aluminum	round
30 cm	5 g	1	1.5	1 m	copper	round
30 cm	5 g	2	1.5	1 m	copper	round
30 cm	5 g	3	1.6	1 m	copper	round
30 cm	10 g	1	1.6	1 m	iron	round
30 cm	10 g	2	1.6	1 m	iron	round
30 cm	10 g	3	1.5	1 m	iron	round

Their question is: "Do arm length and mass of the bob together determine the period of the pendulum?"

Directions: Use the information to fill in this chart so they can answer their question.

Add more rows or columns if you need them.

Period in Seconds

Length of Arm

Mass of Bob	10 cm Trial 1	Trial 2	Trial 3	30 cm Trial 1	Trial 2	Trial 3
1 g						
5 g						
10 g						

4. Thermal Expansion
(Version 1)

Some students had noticed that when water is heated it expands (fills more space). They wondered if different liquids did the same thing. They put different liquids in a thin graduated cylinder. Then they heated water in a pan to a measured temperature and placed the tube upright in the pan for 5 minutes.

They used water, an acid solution (vinegar) and a sugar solution (coca-cola) for the liquids. They heated the water in the pan first to 30°C and tested 3 samples of each liquid at that temperature. Then they heated the water to 90°C and tested 3 more samples of each liquid.

Here is the information they collected.

Amount of water in pan	Liquid	Temperature of water in pan	Sample number	Inside diameter of cylinder	Volume of cold liquid	Volume of heated liquid	Increase in volume	Atmospheric pressure
1 L	water	30°C	1	10 mm	40 mL	44.2 mL	4.2 mL	102 kPa
1 L	water	30°C	2	10 mm	40 mL	44.3 mL	4.3 mL	102 kPa
1 L	water	30°C	3	10 mm	40 mL	44.1 mL	4.1 mL	102 kPa
1 L	water	90°C	1	10 mm	40 mL	45.7 mL	5.7 mL	102 kPa
1 L	water	90°C	2	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	water	90°C	3	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	vinegar	30°C	1	10 mm	40 mL	45.8 mL	5.8 mL	102 kPa
1 L	vinegar	30°C	2	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	vinegar	30°C	3	10 mm	40 mL	45.9 mL	5.9 mL	102 kPa
1 L	vinegar	90°C	1	10 mm	40 mL	47.1 mL	7.1 mL	102 kPa
1 L	vinegar	90°C	2	10 mm	40 mL	47.3 mL	7.3 mL	102 kPa
1 L	vinegar	90°C	3	10 mm	40 mL	47.2 mL	7.2 mL	102 kPa
1 L	coca-cola	30°C	1	10 mm	40 mL	48.8 mL	8.8 mL	102 kPa
1 L	coca-cola	30°C	2	10 mm	40 mL	49.0 mL	9.0 mL	102 kPa
1 L	coca-cola	30°C	3	10 mm	40 mL	48.8 mL	8.8 mL	102 kPa
1 L	coca-cola	90°C	1	10 mm	40 mL	50.1 mL	10.1 mL	102 kPa
1 L	coca-cola	90°C	2	10 mm	40 mL	50.1 mL	10.1 mL	102 kPa
1 L	coca-cola	90°C	3	10 mm	40 mL	50.2 mL	10.2 mL	102 kPa

Their question is: "Do liquid type and the temperature to which they are heated together determine amount of expansion of a liquid?"

Directions: Which of these charts organize best the information they need to answer their questions?

Circle the letter of the best answer.

(a)

Amount of Expansion in mL

	Temperature: 30°C			Temperature: 90°C		
Liquid	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
water	4.2	4.3	4.1	5.7	5.6	5.6
vinegar	5.8	5.6	5.9	7.1	7.3	7.2
coca-cola	8.8	9.0	8.8	10.1	10.1	10.2

(b)

Amount of Expansion in mL

	Temperature	
Liquid	30°C	90°C
water	4.2	5.7
vinegar	5.8	7.1
coca-cola	8.8	10.1

(c)

Amount of Expansion in mL

	Temperature: 30°C			Temperature: 90°C		
Liquid	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
coca-cola	8.8	9.0	8.8	10.1	10.1	10.2

(d)

	Amount of Expansion in mL						Volume of Fluid When Heated					
	Temperature						Temperature					
	30°C			90°C			30°C			90°C		
	Sample No.						Sample No.					
Liquid	1	2	3	1	2	3	1	2	3	1	2	3
water	4.2	4.3	4.1	5.7	5.6	5.6	44.2	44.3	44.1	45.7	45.6	45.6
vinegar	5.8	5.6	5.9	7.1	7.3	7.2	45.8	45.6	45.9	47.1	47.3	47.2
coca-cola	8.8	9.0	8.8	10.1	10.1	10.2	48.8	49.0	48.8	50.1	50.1	50.2

(e)

Volume of Fluid When Heated

	Temperature: 30°C			Temperature: 90°C		
Liquid	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
water	44.2	44.3	44.1	45.7	45.6	45.6
vinegar	45.8	45.6	45.9	47.1	47.3	47.2
coca-cola	48.8	49.0	48.8	50.1	50.1	50.2

4. Thermal Expansion
(Version 2)

Some students had noticed that when water is heated it expands (fills more space). They wondered if different liquids did the same thing. They put different liquids in a thin graduated cylinder. Then they heated water in a pan to a measured temperature and placed the tube upright in the pan for 5 minutes.

They used water, an acid solution (vinegar) and a sugar solution (coca-cola) for the liquids. They heated the water in the pan first to 30°C and tested 3 samples of each liquid at that temperature. Then they heated the water to 90°C and tested 3 more samples of each liquid.

Here is the information they collected.

Amount of water in pan	Liquid	Temperature of water in pan	Sample number	Inside diameter of cylinder	Volume of cold liquid	Volume of heated liquid	Increase in volume	Atmospheric pressure
1 L	water	30°C	1	10 mm	40 mL	44.2 mL	4.2 mL	102 kPa
1 L	water	30°C	2	10 mm	40 mL	44.3 mL	4.3 mL	102 kPa
1 L	water	30°C	3	10 mm	40 mL	44.1 mL	4.1 mL	102 kPa
1 L	water	90°C	1	10 mm	40 mL	45.7 mL	5.7 mL	102 kPa
1 L	water	90°C	2	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	water	90°C	3	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	vinegar	30°C	1	10 mm	40 mL	45.8 mL	5.8 mL	102 kPa
1 L	vinegar	30°C	2	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	vinegar	30°C	3	10 mm	40 mL	45.9 mL	5.9 mL	102 kPa
1 L	vinegar	90°C	1	10 mm	40 mL	47.1 mL	7.1 mL	102 kPa
1 L	vinegar	90°C	2	10 mm	40 mL	47.3 mL	7.3 mL	102 kPa
1 L	vinegar	90°C	3	10 mm	40 mL	47.2 mL	7.2 mL	102 kPa
1 L	coca-cola	30°C	1	10 mm	40 mL	48.8 mL	8.8 mL	102 kPa
1 L	coca-cola	30°C	2	10 mm	40 mL	49.0 mL	9.0 mL	102 kPa
1 L	coca-cola	30°C	3	10 mm	40 mL	48.8 mL	8.8 mL	102 kPa
1 L	coca-cola	90°C	1	10 mm	40 mL	50.1 mL	10.1 mL	102 kPa
1 L	coca-cola	90°C	2	10 mm	40 mL	50.1 mL	10.1 mL	102 kPa
1 L	coca-cola	90°C	3	10 mm	40 mL	50.2 mL	10.2 mL	102 kPa

Their question is: "Do type of liquid and temperature to which they are heated together determine amount of expansion of a liquid?"

Amount of Expansion in mL

Temperature

Liquid		30°C Sample 1	Sample 2	Sample 3	90°C Sample 1	Sample 2	Sample 3
water	(s)	(a)	(b)	(c)	(d)	(e)	(f)
vinegar	(t)	(g)	(h)	(i)	(j)	(k)	(l)
coca-cola	(u)	(m)	(n)	(o)	(p)	(q)	(r)

1. How should they record the information that the 2nd sample of coca-cola expanded 9.0 mL when heated to 30°C?

   Circle the number of the correct answer.

   (i) Put 9.0 in space (n).

   (ii) Put 9.0 in space (q).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

2. How should they record the fact that the volume of each sample when cold was 40 mL?

   Circle the number of the correct answer.

   (i) Put this information in each of the spaces (a) to (r).

   (ii) Put this information in the spaces (s), (t) and (u).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

3. How should they record the information about the amount of expansion of the 3 samples of vinegar heated to 90°C?

   Circle the number of the correct answer.

   (i) Put 7.1, 7.3 and 7.2 in spaces (j), (k) and (l).

   (ii) Put 7.1, 7.3 and 7.2 in spaces (g), (h) and (i).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

4. How should they record the information about the volume of each sample of vinegar when heated?

   Circle the number of the correct answer.

   (i) Put each volume in each of the spaces (g) to (l).

   (ii) Put each volume in each of the spaces (a) to (f).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

4. Thermal Expansion
(Version 3)

Some students had noticed that when water is heated it expands (fills more space). They wondered if different liquids did the same thing. They put different liquids in a thin graduated cylinder. Then they heated water in a pan to a measured temperature and placed the tube upright in the pan for 5 minutes.

They used water, an acid solution (vinegar) and a sugar solution (coca-cola) for the liquids. They heated the water in the pan first to 30°C and tested 3 samples of each liquid at that temperature. Then they heated the water to 90°C and tested 3 more samples of each liquid.

Here is the information they collected.

Amount of water in pan	Liquid	Temperature of water in pan	Sample number	Inside diameter of cylinder	Volume of cold liquid	Volume of heated liquid	Increase in volume	Atmospheric pressure
1 L	water	30°C	1	10 mm	40 mL	44.2 mL	4.2 mL	102 kPa
1 L	water	30°C	2	10 mm	40 mL	44.3 mL	4.3 mL	102 kPa
1 L	water	30°C	3	10 mm	40 mL	44.1 mL	4.1 mL	102 kPa
1 L	water	90°C	1	10 mm	40 mL	45.7 mL	5.7 mL	102 kPa
1 L	water	90°C	2	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	water	90°C	3	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	vinegar	30°C	1	10 mm	40 mL	45.8 mL	5.8 mL	102 kPa
1 L	vinegar	30°C	2	10 mm	40 mL	45.6 mL	5.6 mL	102 kPa
1 L	vinegar	30°C	3	10 mm	40 mL	45.9 mL	5.9 mL	102 kPa
1 L	vinegar	90°C	1	10 mm	40 mL	47.1 mL	7.1 mL	102 kPa
1 L	vinegar	90°C	2	10 mm	40 mL	47.3 mL	7.3 mL	102 kPa
1 L	vinegar	90°C	3	10 mm	40 mL	47.2 mL	7.2 mL	102 kPa
1 L	coca-cola	30°C	1	10 mm	40 mL	48.8 mL	8.8 mL	102 kPa
1 L	coca-cola	30°C	2	10 mm	40 mL	49.0 mL	9.0 mL	102 kPa
1 L	coca-cola	30°C	3	10 mm	40 mL	48.8 mL	8.8 mL	102 kPa
1 L	coca-cola	90°C	1	10 mm	40 mL	50.1 mL	10.1 mL	102 kPa
1 L	coca-cola	90°C	2	10 mm	40 mL	50.1 mL	10.1 mL	102 kPa
1 L	coca-cola	90°C	3	10 mm	40 mL	50.2 mL	10.2 mL	102 kPa

Their question is: "Do type of liquid and temperature to which they are heated together determine amount of expansion of a liquid?"

Directions: Use the information to fill in this chart so they can answer their questions.

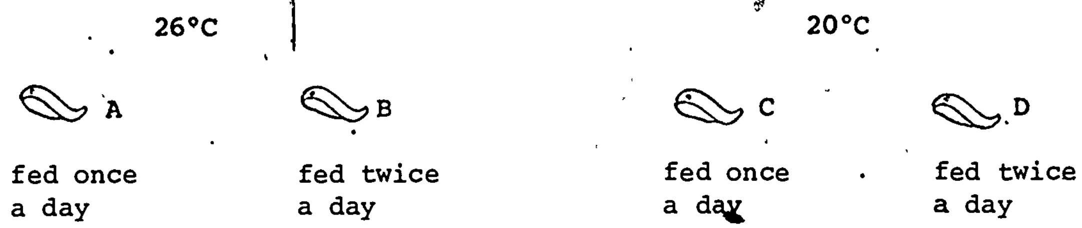
Add more rows or columns if you need them.

Amount of Expansion in mL

	Temperature					
	30°C			90°C		
Liquid	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
water						
vinegar						
coca-cola						

5. Goldfish
   (Version 1)

The class studied what happened to the growth of goldfish when they were kept in 2 different temperatures of water and fed two different amounts of food. They put 4 identical fish in 4 identical tanks. Fish A and B were put in water at 26°C. Fish C and D were placed in water with a temperature of 20°C. All were fed the same amount of food at the same time each day. Twelve hours later fish B and D were given an extra feeding, also of the same amount.



The gain in mass between day 1 and day 21 was calculated for each fish.

Here are the notes they kept of their experiment.

Water Temperature	Goldfish	Number of plants in tank	Initial Mass	Feedings per day	Mass After 3 weeks	Gain in Mass
26°C	A	4	1 g	1	1.5 g	.5 g
26°C	B	3	1 g	2	2.8 g	1.8 g
20°C	C	6	1 g	1.	2.1 g	1.1 g
20°C	D	4	1 g	2	3.0 g	2.0 g

This is the question the class would like to answer: "Do the number of feedings per day and the temperature of the water in the tank together determine the increase in mass of the fish?"

Directions: Which of these charts best organizes the information they need to answer their question?

Circle the letter of the best answer.

(a)

	Gain in Mass	
Water Temperature	Fed Once a Day	Fed Twice a Day
20°C	1.1 g	2.0 g

(b)

	Initial Mass		Mass After 3 Weeks		Gain in Mass	
Water Temperature	Fed Once a Day	Fed Twice a Day	Fed Once a Day	Fed Twice a Day	Fed Once a Day	Fed Twice a Day
26°C	1 g	1 g	1.5 g	2.8 g	.5 g	1.8 g
20°C	1 g	1 g	2.1 g	3.0 g	1.1 g	2.0 g

(c)

	Gain in Mass
Water Temperature	Fed Twice a Day
26°C	1.8 g
20°C	2.0 g

(d)

Water Temperature	Initial Mass
26°C	Fish A: 1 g Fish B: 1 g
20°C	Fish C: 1 g Fish D: 1 g

(e)

	Gain in Mass	
Water Temperature	Fed Once a Day	Fed Twice a Day
26°C	.5 g	1.8 g
20°C	1.1 g	2.0 g

5. Goldfish
(Version 2)

The class studied what happened to the growth of goldfish when they were kept in 2 different temperatures of water and fed two different amounts of food. They put 4 identical fish in 4 identical tanks. Fish A and B were put in water at 26°C. Fish C and D were placed in water with a temperature of 20°C. All were fed the same amount of food at the same time each day. Twelve hours later fish B and D were given an extra feeding, also of the same amount.

26°C 20°C

A fed once a day

B fed twice a day

C fed once a day

D fed twice a day

The gain in mass between day 1 and day 21 was calculated for each fish.

Here are the notes they kept of their experiment.

Water Temperature	Goldfish	Number of plants in tank	Initial Mass	Feedings per day	Mass After 3 weeks	Gain in Mass
26°C	A	4	1 g	1	1.5 g	.5 g
26°C	B	3	1 g	2	2.8 g	1.8 g
20°C	C	6	1 g	1	2.1 g	1.1 g
20°C	D	4	1 g	2	3.0 g	2.0 g

Here is the question the class would like to answer: "Do the number of feedings per day and the temperature of the water in the tank together determine the increase in mass of the fish?"

The class made up this chart to organize the information to answer their question.

Water Temperature	Gain in Mass Fed Once a Day	Fed Twice a Day
26°C (e)	(a)	(b)
20°C (f)	(c)	(d)

1. How should they record the information about the initial mass?

   Circle the number of the correct answer.

   (i) Put 1 g in the spaces (a) to (d).

   (ii) Put 1 g in the spaces (e) to (f).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

2. How should they record that goldfish D had a gain in mass of 2.0 g?

   Circle the number of the correct answer.

   (i) Put 2.0 g in space (d).

   (ii) Put 2.0 g in space (b).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

3. How should they record the fact that the difference in the water temperatures they used was 6°C?

   Circle the number of the correct answer.

   (i) Put 6.0°C in spaces (a) and (c).

   (ii) Put 6.0°C in space (f).

   (iii) Leave it out.

   (iv) Make up a new space for the information.

4. How should they record the information about the number of plants in the tanks?

   Circle the number of the correct answer.

   (i) Put these numbers in spaces (a) to (d).

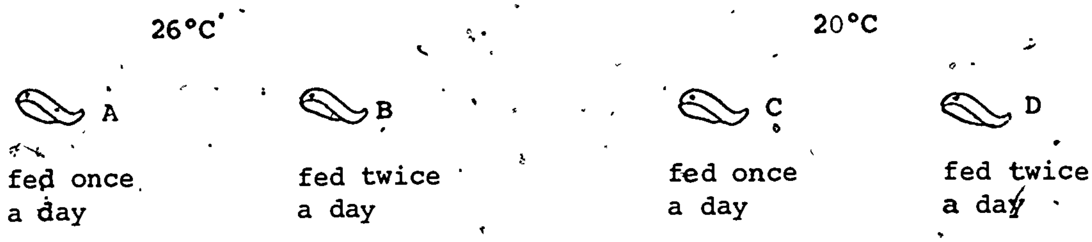
   (ii) Put these numbers in spaces (e) and (f).

   (iii) Leave it out.

   (iv) Make up new spaces for the information.

5. Goldfish
(Version 3)

The class studied what happened to the growth of goldfish when they were kept in 2 different temperatures of water and fed two different amounts of food. They put 4 identical fish in 4 identical tanks. Fish A and B were put in water at 26°C. Fish C and D were placed in water with a temperature of 20°C. All were fed the same amount of food at the same time each day. Twelve hours later fish B and D were given an extra feeding, also of the same amount.



The gain in mass between day 1 and day 21 was calculated for each fish.

Here are the notes they kept of their experiment.

Water Temperature	Goldfish	Number of plants in tank	Initial Mass	Feedings per day	Mass After 3 weeks	Gain in Mass
26°C	A	4	1 g	1	1.5 g	.5 g
26°C	B	3	1 g	2	2.8 g	1.8 g
20°C	C	6	1 g	1	2.1 g	1.1 g
20°C	D	4	1 g	2	3.0 g	2.0 g

Here is the question that the class would like to answer: "Do the number of feedings per day and the temperature of the water in the tank together determine the increase in mass of the fish?"

Directions: Use the information from the table to fill in the following chart so the class can answer their question.

Add more rows or columns if you need them.

Water Temperature	Gain in Mass Fed Once a Day	Fed Twice a Day
26°C		
20°C		

E. OBSERVING RELATIONSHIPS - Intermediate Levels 2 - 5

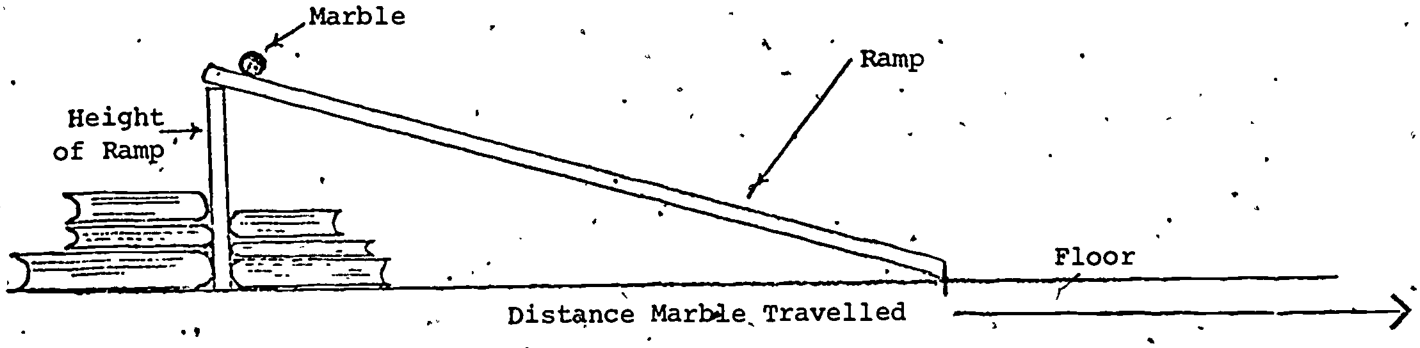
Answer Sheet

	Levels 2	3	4	5
1. Ramp	c	d	b	a
2. Growth of Plants - Water	a	c	b	d
3. Heat Conduction (a)	b	d	a	c
4. Coasting on a Bicycle	d	a	c	b
5. Thermal Expansion	a	d	b	c
6. Heat Conduction (b)	c	b	a	d

Intermediate Advanced

	Levels 0	3	4	5	6
1. Ramp (a) - Distance	--	b or d	--	a or e	c
2. Coasting on a Bicycle	d	a or f	--	b or c	e
3. Growth of Seedlings - Soil and Water	--	b or d	--	a or c	e
4. Conduction of Heat (a)	--	b or c	--	d	a
5. Thermal Expansion	--	a or d	--	c	b
6. Conduction of Heat (b)	--	a or b	--	c	d
7. Ramp (b) - Time	--	a or d	--	b or e	c

1. Ramp



Richard did an experiment in which marbles of different mass rolled down a ramp. He wanted to find out if the distance travelled by each marble is influenced by the mass of the marble.

These were his results:

	Distance Travelled by Marble		
Trial	1 g marble	2 g marble	3 g marble
1st	12	17	24
2nd	14	16	22
3rd	11	19	23
4th	15	14	18
5th	9	15	25

Directions: What would be the best way to find out if there is a relationship between the mass of the marble and the distance it travels down the ramp?

Circle the letter of the best answer.

(a) Calculate the average distance travelled for each marble down each column. See if the average distance travelled increases as the mass of the marble increases.

(b) Look at all the information. See if the distance travelled is always longer as the marble's mass gets bigger.

(c) Find the longest and shortest distance travelled. See if the marble's mass is bigger for the longest distance than it is for the shortest distance.

(d) Compare the distance the marble travelled on the middle trial for each marble. See if the distance increases as the mass of the marble increases.

2. Growth of Plants - Water

A class is studying the effect of the amount of water on the growth of radish seedlings. They decided to plant radish seeds in 12 pots filled with garden soil. Four of the pots received .01 L of water daily; four pots received .03 L of water daily and the other four pots received .05 L of water daily. They were careful to keep everything else the same for each of the seedlings. After 3 weeks the heights of the seedlings were measured.

Here are the results of the experiment:

Amount of Water Given Daily	Height of Seedlings After 3 Weeks			
	Plant 1	Plant 2	Plant 3	Plant 4
.01 L	6.2 cm	5.8 cm	6.0 cm	6.1 cm
.03 L	10.1 cm	9.7 cm	9.9 cm	10.3 cm
.05 L	12.0 cm	11.8 cm	12.2 cm	11.9 cm

Directions: What would be the best way for the class to find out if the heights of the seedlings are affected by the amounts of water given daily?

Circle the letter of the best answer.

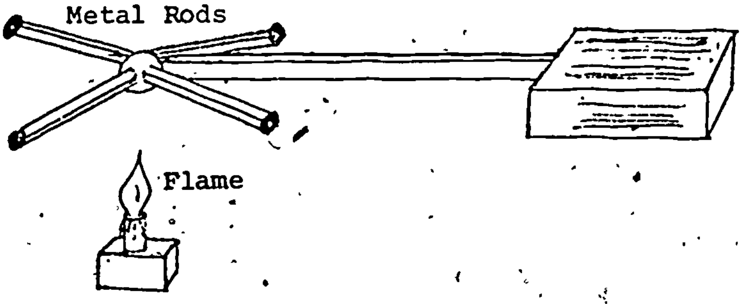
(a) Find the tallest and the shortest heights of the seedlings. See if the amount of water is greater for the tallest seedling than it is for the shortest seedling.

(b) Look at all the data in the table. As the amount of water increases see if the height of the seedlings changes.

(c) Compare the heights of each plant 3. See if the height of the seedlings changes as the amount of water added daily increases.

(d) Calculate the average height of the seedlings across each row. See if the average height for each row changes as the amount of water added daily increases.

3. Heat Conduction (a)



Mr. Simpson's class did an experiment to see if various metals conduct heat at different rates. A conductometer was used. A spot of wax was placed at the tip of each of the four metal rods. A flame was positioned 4 cm from the centre of the conductometer. The time taken for each spot of wax to melt off was recorded.

Here are the notes kept by the class:

Time to Melt Wax (in seconds)

Trials	Copper	Aluminum	Brass	Iron
1st	58	80	103	179
2nd	60	79	102	180
3rd	61	79	100	178
4th	62	83	97	183

Directions: What would be the best way to find out if there is a relationship between the type of metal and its ability to conduct heat?

Circle the letter of the best answer.

(a) Look at all of the information. See if the time taken to melt the wax is always different for different metals.

(b) Find the least and greatest times taken to melt the wax. See if these two times are different for different metals.

(c) Calculate the average time taken to melt the wax for each metal (the average of each column). See if the average time is different for different metals.

(d) Compare the times taken to melt the wax on the third trial. See if the time taken to melt the wax is affected by the type of metal.

4. Coasting on a Bicycle

Jim did an experiment in which boys of different masses coasted down a hill on similar Sekine 10 speed bikes. The point from which the boys started coasting was 20 m up the hill. Each boy made 3 trial runs from that height. Jim measured the distances the boys coasted before they had to pedal the bike to keep their balance.

Here are his notes:

	Distance Coasted		
Trials	Bill (30 kg)	Mike (35 kg)	Gord (40 kg)
1st	30 m	36 m	40 m
2nd	29 m	35 m	39 m
3rd	31 m	34 m	41 m

Directions: What would be the best way to find out if there is a relationship between the mass of the boy and the distance he coasts down the hill?

Circle the letter of the best answer.

(a) Compare the distance that each boy coasted on their second trials. See if distance coasted increases as the mass of the boy increases.

(b) Calculate the average distance coasted for each boy down each column of the table. See if the average distance coasted increases as the mass of the boy increases.

(c) Look at all the information. As the mass of the boy increases see if distance coasted always increases.

(d) Find the longest and shortest distance coasted. See if the mass of the boy is greater for the longest distance coasted than it is for the shortest distance coasted.

5. Thermal Expansion

Susan did an experiment to discover the effect of heat on a liquid. The liquid she chose was water. She put a given volume of water, 40 mL in each of 4 graduated cylinders. She heated each cylinder to 30°C and measured the change in the volume of the water in each cylinder. Susan repeated this same procedure by heating the same volume of water in each of four cylinders to 60°C and finally to 90°C. She recorded the change in volume in each graduated cylinder.

Here are the notes she kept:

Temperature to Which Water was Heated	Change in Volume Graduated Cylinders of Water 1st	2nd	3rd	4th
30°C	4.2	4.3	4.1	4.3
60°C	4.8	4.9	4.8	4.7
90°C	5.7	5.6	5.6	5.8

Directions: What would be the best way for Susan to find out if there is a relationship between the amount of heat applied to a liquid and the effect on the volume of the liquid?

Circle the letter of the best answer.

(a) Find the greatest and least volume change. See if the temperature to which the water was heated is higher for the greatest change in volume than for the least change in volume.

(b) Look at all the data in the table. As the temperature of the water increases see if the change in volume always increases.

(c) Calculate the average change in volume across each row of the table for each temperature. See if the average change in volume increases as the temperature increases.

(d) Compare the changes in volume in the cylinders of water for the third trial. See if these changes in volume get larger as the temperature of the water gets higher.

6. Heat Conduction (b)

Mr. Murphy's class did an experiment to see if the thickness of the bottoms of aluminum pots affected the length of time required to heat the same volumes of water to boiling point (100°C). Three pots with 1 mm thick bottoms were heated and the class measured the time required to boil the water. This same procedure was repeated for three pots with 2 mm thick bottoms and with 3 mm thick bottoms.

Here are their notes:

Time Required for Water to Reach Boiling Point

Thickness of Pot Bottoms	Aluminum Pots 1	2	3
1 mm	6 min	5.8 min	6.1 min
2 mm	7.9 min	8 min	8.2 min
3 mm	9.7 min	9.9 min	10.1 min

Directions: What would be the best way for the class to find out if the thickness of the pot bottoms affects the time required to boil the water?

Circle the letter of the best answer.

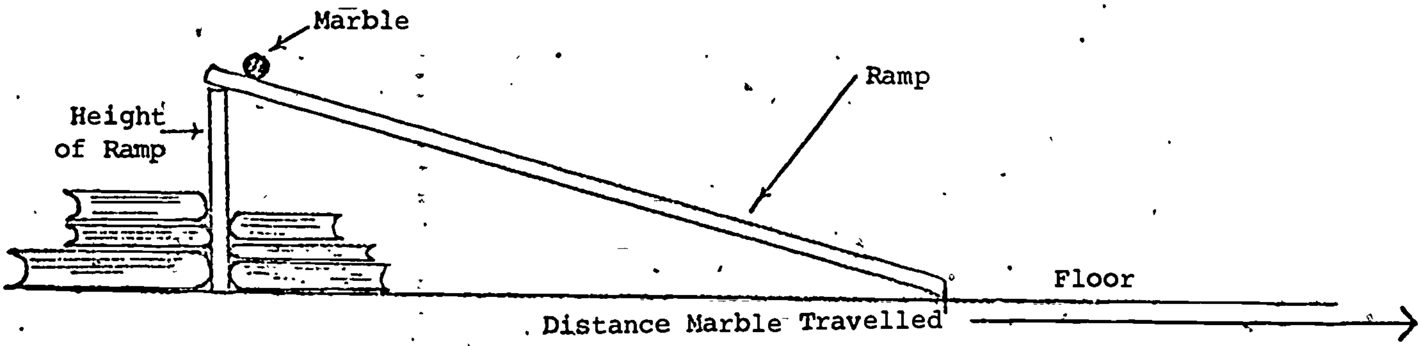
(a) Look at all the data in the table. As the time required to boil water increases, see if the thicknesses of the bottoms always increase.

(b) Compare the results for the 3rd pots. See if the time required to boil water increases as the thickness of the bottoms increases.

(c) Find the least and greatest times required to boil the water. See if the pot bottom was thicker for the longest time than it was for the shortest time.

(d) Calculate the average time required to boil water across each row for each bottom thickness. See if the average time increases as the thickness of the bottoms increases.

1. Ramp (a) - Distance



Richard did an experiment in which marbles of different mass rolled down a ramp. A 1 g marble was rolled three times down a ramp 10 cm high. The distance travelled on each trial was measured. The experiment was repeated using 2 g and 3 g marbles on ramps that were 10 cm, 15 cm and 20 cm high. The distances for each set of trials were averaged.

Here are Richard's results:

Height of Ramp	Average Distance Rolled 1 g marble	2 g marble	3 g marble
10 cm	20 cm	40 cm	80 cm
15 cm	30 cm	60 cm	120 cm
20 cm	40 cm	80 cm	160 cm

Directions: What would be the best way for Richard to find out if the mass of the marble affects how far the marble will roll when the height of the ramp is changed?

Circle the letter of the best answer.

(a) Calculate the average distance travelled for the marbles in each row of the table. See if the distance travelled increases as the height of the ramp increases, when the mass of the marble is averaged.

(b) Study the data for the 15 cm ramp. See if the average distance the marble rolls increases with the mass of the marble.

(c) See if the mass of the marble affects how far it rolls when the ramp is 10 cm high. See if the same effect of mass of the marble on distance is shown for the other ramp heights.

(d) Study the data for the 2 g marble. See if the average distance rolled increases as the height of the ramp increases.

(e) Calculate the average distance travelled for each marble in each column of the table. See if the distance travelled increases as the mass of the marble increases, when the height of the ramp is averaged.

2. Coasting on a Bicycle

Jim did an experiment in which boys of different masses coasted down a hill on similar bikes. The height of the starting point was changed for different trials. Jim measured the distances that the boys travelled before they had to pedal to keep the bikes balanced.

Here are Jim's results:

Height of Start on Hill	Distance Travelled Bill (30 kg)	Mike (35 kg)	Gord (40 kg)
20 m	30 m	35 m	40 m
30 m	45 m	52 m	60 m
40 m	60 m	70 m	80 m

Directions: What would be the best way for Jim to find out if the boys' mass affects how far they will coast when they start at different heights on the hill?

Circle the letter of the best answer.

(a) Study the data for Gord. See if the distance he travels increases as the height of the starting point on the hill increases.

(b) Calculate the average distance travelled by each boy down each column of the table. See if the average distance travelled increases as the mass of the boys increases.

(c) Calculate the average distance travelled for the boys at each height across each row of the table. See if the average distance travelled increases as the height of the starting point on the hill increases.

(d) Calculate the average starting height on the hill. See if the average starting height affects the mass of the boys.

(e) See if the boys' mass affects how far they coast when the starting point is 20 m high. See if the same effect of the boys' mass on the distance travelled is shown for the other starting points on the hill.

(f) Study the data for the 30 m high starting point. See if the distance that the boys coast increases with the mass of the boy riding the bike.

3. Growth of Seedlings - Soil and Water

A class is studying the effect of the type of soil and the amount of water on the growth of radish seedlings. They planted radish seeds in three pots containing sand and in three similar pots containing garden soil. To one pot of sand and one pot of garden soil .01 L of water was added daily. To one pot of sand and 1 pot of garden soil .03 L of water was added daily. Similarly, to the remaining pot of sand and pot of garden soil .05 L of water was added daily. They were careful to keep everything else the same for each of the seedlings. They measured the height of the seedlings after 3 weeks.

Here are the notes of their experiment:

Amount of Water Given Daily	Height of Seedling in Three Weeks	
	Sand	Garden Soil
.01 L	4.0 cm	6.0 cm
.03 L	6.0 cm	8.0 cm
.05 L	8.0 cm	10.0 cm

Directions: What would be the best way for the class to find out if the height of the seedlings is affected by the type of soil when different amounts of water are given daily?

Circle the letter of the best answer.

(a) Calculate the average height of the seedlings across each row of the table. See if the average height of the seedlings is affected by the amount of water given daily.

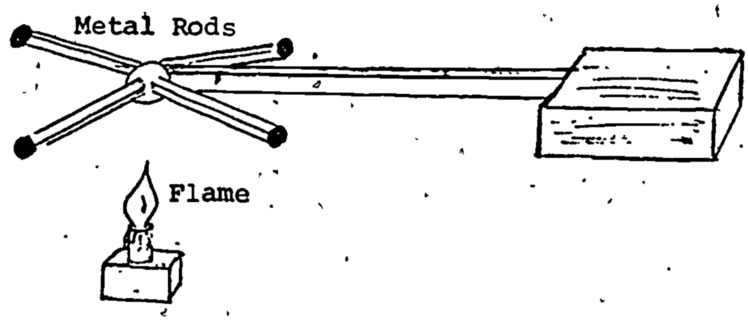
(b) Study the data for .05 L of water. See if the height of the seedlings is affected by the type of soil.

(c) Calculate the average height of the seedlings down each column of the table. See if the average height of the seedlings is affected by the type of soil in the pots.

(d) Study the data for sand. See if the height of the seedlings is affected by the amount of water given daily.

(e) See if the amounts of water given daily affect the height of the seedlings in the sand. See if the same effect is true for the seedlings in garden soil.

4. Heat Conduction (a)



Mrs. Simpon's class did an experiment to find out if various metals conduct heat at different rates. A conductometer was used. A spot of wax was placed at the tip of each of the four metal rods. The flame was positioned 2 cm from the centre of the conductometer and the time taken for each spot of wax to drop was recorded. The experiment was repeated with the flame 4 cm from the centre of the conductometer.

Here are the results:

	Time to Melt Wax (in seconds)			
Distance of Flame	Copper	Aluminum	Brass	Iron
2 cm	30	40	50	90
4 cm	60	80	100	180

Directions: What would be the best way for the students to find out if the time needed to melt the wax is affected by the type of metal when the flame is placed at different distances?

Circle the letter of the best answer.

(a) See if the type of metal affects the time required to melt the wax when the distance of the flame is 2 cm. See if this same effect is true for the 4 cm distance of flame.

(b) Study the data for the 2 cm distance. See if the time required to melt the wax is affected by the type of metal used.

(c) Study the data for the aluminum metal rod. See if the time required to melt the wax increases as the distance of the flame from the rod increases.

(d) Calculate the average of the times required to melt the wax across each row of the table. See if the average time to melt the wax increases as the distance of the flame increases.

5. Thermal Expansion

Some students performed an experiment to study the effect of heat on three types of liquid. They heated in a graduated cylinder the same volume of water, an acid solution (vinegar), and a sugar solution (coca-cola) to 30°C and recorded the changes in the volume of each liquid. The experiment was repeated, heating the same volumes of each liquid to 60°C, and again, heating the same volumes of each liquid to 90°C.

Here are the results of the experiment:

Temperature to Which Liquids were Heated	Change in Volume (in mL) Water	Acid Solution	Sugar Solution
30°C	4.0	5.0	10.0
60°C	8.0	10.0	20.0
90°C	12.0	15.0	30.0

Directions: What would be the best way for the students to find out if the change in the volume of each liquid is affected by the temperature to which it is heated when different liquids are used?

Circle the letter of the best answer.

(a) Study the information for the 60°C temperature. See if the change in volume of the liquids is affected by the type of liquid.

(b) See if the change in the volume of the water increases as the temperature to which it was heated increases. See if the same relationship is true for the acid solution and the sugar solution.

(c) Calculate the average change in volume across each row of the table. See if the average change in volume increases as the temperature to which the liquids were heated increases.

(d) Study the information for the acid solution. See if the change in volume has increased as the temperature increases.

6. Heat Conduction (b)

Carol did an experiment to find which kinds of pots are best for fast cooking. She used aluminum and copper pots with different thicknesses of bottoms. The same amounts of water at the same starting temperatures were set to boil on identical hot plates. She then recorded the time required for each pot of water to reach boiling point (100°C).

Her notes from the experiment are below:

	Time Required for Water to Reach Boiling Point (100°C)	
Thickness of Bottom	Aluminum	Copper
1 mm	6 min	5 min
2 mm	8 min	7 min
3 mm	10 min	9 min

Directions: What would be the best way for Carol to find out if the thickness of the metal affects the time required to boil water when pots of different metals are used?

Circle the letter of the best answer.

(a) Study the information for the 2 mm thickness of the bottom of each pot. See if the time required to boil the water is affected by the type of pot.

(b) Study the information for the copper pot. See if the time required to boil the water increases with the thickness of the bottom.

(c) Calculate the average of the times required to boil water across each row of the table. See if the average time required to boil water increases as the thickness of the bottom of the pots increases.

(d) See if the thickness of the bottom of the aluminum pots affects the time required to boil water. See if the same effect of bottom thickness is shown for the copper pots.

7. Ramp (b) - Time

Mary did an experiment in which marbles of 1 g, 2 g and 3 g were rolled down a ramp. Three ramp heights of 10 cm, 20 cm and 30 cm were used. Each marble was released at each height and the length of time it took the marble to come to rest was measured.

Here are Mary's results:

Height of Ramp	Length of Time The Marble Rolled		
	1 g marble	2 g marble	3 g marble
10 cm	1.0 s	1.5 s	2.0 s
20 cm	1.5 s	2.0 s	2.5 s
30 cm	2.0 s	2.5 s	3.0 s

Directions: What would be the best way for Mary to find out if the size of the marble affects the length of time it takes the marble to come to rest when the height of the ramp is changed?

Circle the letter of the best answer.

(a) Study the data for the 30 cm ramp. See if the time that the marble rolls increases with the mass of the marble.

(b) Calculate the average time for the marbles across each row of the table. See if the average time increases as the height of the ramp increases.

(c) See if the mass of the marble affects the length of time that it rolls when the ramp is 10 cm high. See if the same effect of the marble's mass on time is shown for the other ramp heights.

(d) Study the data for the 2 g marble. See if the time the marble rolls increases as the height of the ramp increases.

(e) Calculate the average time for each marble mass by averaging down each column of the table. See if the average time increases as the mass of the marble increases.

F. CONCLUDING - Intermediate

	Levels 0	2	3	4
1. Ramp (a) - distance	a or c	d or e	f	b
2. Bicycle	b or c	a or f	d	e
3. Radiation	c or d	b or f	a	e
4. Heat Conduction	d or f	a or e	c	b
5. Fish	c or e	b or d	f	a
6. Thermal Expansion	a or b	c or f	e	d
7. Pendulum	e or f	a or b	d	c
8. Heat Conduction	b or e	c or d	a	f
9. Ramp (b) - time	a or e	b or f	c	d
10. Growth of Plants	c or e	d or f	b	a

1. Ramp (a) - Distance

Richard built a ramp and rolled a marble down it to see how far it would travel across the floor. He decided to learn more. He rolled 3 marbles down the ramp when it was resting on a support 10 cm high, then repeated the rolls, using the same 3 marbles, when the ramp was 20 cm high and 30 cm high. He was careful to do everything the same each time he started a marble down the ramp. He got these results.

Distance Marble Rolled

Height of Ramp	1 g marble	2 g marble	3 g marble
10 cm	60 cm	120 cm	240 cm
20 cm	120 cm	240 cm	360 cm
30 cm	180 cm	360 cm	480 cm

Here are some statements about the results of the experiment.

1. As the height of the ramp was increased the distance the marble travelled also increased.

2. As the distance the marble travelled increased the mass of the marble decreased.

3. As the mass of the marble increased the distance the marble travelled also increased.

4. The distance the marble travelled was determined by the mass of the marble and ramp height together.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 1 and statement 2 together.

(b) Statements 1, 3 and 4 together.

(c) Statement 2 only.

(d) Statement 3 only.

(e) Statement 1 only.

(f) Statement 1 and statement 3 together.

2. Bicycle

Jim tried to find out why some people coast further on their bicycles than others do. He gathered three of his classmates, Bill, Terry and Sam, who all had the same kind of bicycles, at the top of a hill near the school.

One at a time each coasted down the hill from a still start. Jim measured how far each travelled before needing to pedal to keep the bike balanced.

They then repeated the experiment from a still start position half way up the hill. These were the results.

	Distance Travelled Without Pedalling	
Boy's Mass	Start Half Way Up Hill	Start at Top of Hill
35 kg	160 m	320 m
36 kg	175 m	350 m
41 kg	195 m	390 m

Here are some statements about the results of the experiment.

1. The distance the boys could coast was determined by their mass and the height of the starting point together.
2. As the mass of the boys increased, the distance the bike travelled also increased.
3. As the height from which they started increased, the distance travelled also increased.
4. Increasing the mass of the boy increased the height of the starting point and the distance the bike travelled.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 3 only.

(b) Statement 4 and statement 2 together.

(c) Statement 4 only.

(d) Statement 2 and statement 3 together.

(e) Statement 1, 2 and 3 together.

(f) Statement 2 only.

3. Radiation and Heat Absorption

Lyle did an experiment. He had six tin cans that were exactly the same. He painted each can a different colour or finish. Then he filled each can with 1 L of water at room temperature. A thermometer was placed in each can. Each can was placed 20 cm from a 250 watt lamp. After 30 minutes the temperature change in each can was recorded. Here are the results.

	Temperature Change of Water After 30 min in °C	
Colour	Dull Finish	Shiny Finish
Black	20	10
Dark Green	16	8
White	12	6

Here are some statements about the results of the experiment.

1. When dull paint was used the temperature change of the water was greater than when shiny paint was used.

2. The temperature change of the water was determined by the colour and the dullness/shininess of the finish together.

3. The temperature of the water and the colour of the paint were both less when the surface was dull rather than shiny.

4. The temperature change was greater when the colour was darker.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 1 and statement 4 together.

(b) Statement 1 only.

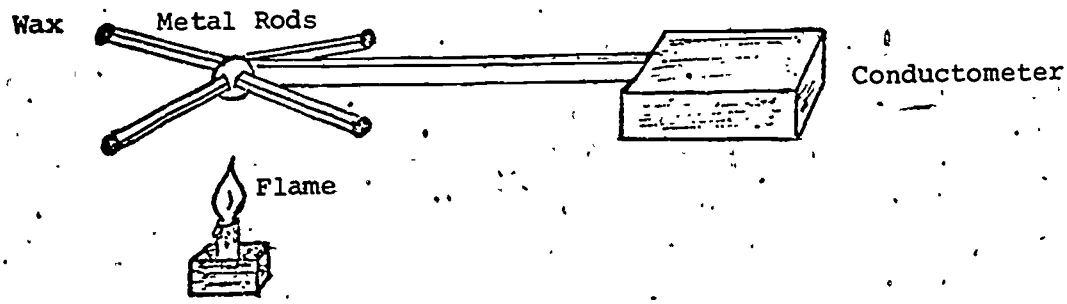
(c) Statement 3 only.

(d) Statement 1 and statement 3 together.

(e) Statements 1, 2 and 4 together.

(f) Statement 4 only.

4. Heat Conduction



Mr. Black's class did an experiment with a conductometer. A spot of wax was placed at the tip of each of four metal rods. The flame was placed 2 cm from the centre of the conductometer and the time taken for each spot of wax to drop off was recorded. The experiment was repeated with the flame 4 cm from the centre of the conductometer. Here are the results.

Time Required to Melt Wax (in seconds)

Metal	Flame 2 cm Away	Flame 4 cm Away
Copper	30	60
Aluminum	40	80
Brass	50	100
Iron	90	180

Here are some statements about the results of the experiment.

1. The melting time was determined by the type of metal and the distance of the flame together.

2. The increase in melting time affected the type of metal and the distance of the flame.

3. The time required to melt the wax was affected by the type of metal in the rod.

4. When the distance of the flame from the conductometer was increased, the time taken for the wax to melt also increased.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 4 only.

(b) Statements 1, 3 and 4 together.

(c) Statement 3 and statement 4 together.

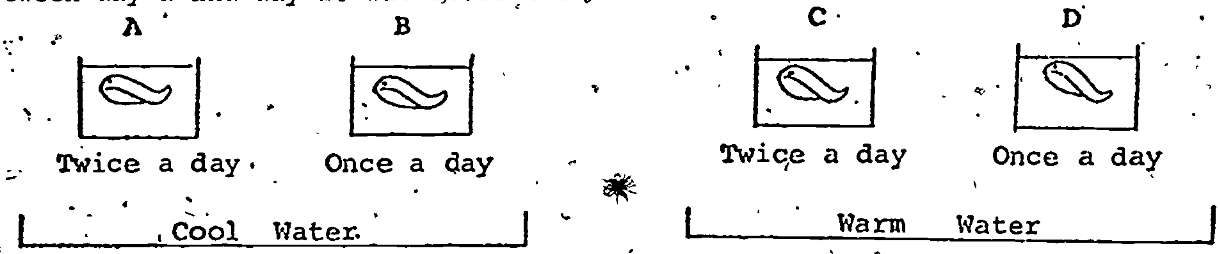
(d) Statement 2 and statement 4 together.

(e) Statement 3 only.

(f) Statement 2 only.

5. Fish

The grade 7 science class did a study with goldfish. They put an identical fish in each of four tanks. Fish A and B were kept in cool water. Fish C and D were kept in warm water. Fish A and C were fed twice a day for 20 days while the other 2 were only fed once a day. The gain in mass of the fish between day 1 and day 20 was recorded.



Results:

		Mass Gain
Cool Water	Twice a day	2 g
	Once a day	1 g
Warm Water	Twice a day	1 g
	Once a day	.5 g

Here are some statements about the results of the experiment.

1. The experiment with the fish showed that if we gave the fish more to eat, their amount of growth was greater.

2. The experiment with the fish showed that the fish grew more if they were kept in cool water rather than warm water.

3. When the quantity of food given the fish was decreased over a period of time the growth of the fish doubled, even when the temperature of the water was changed.

4. The experiment with the fish showed that the growth of the fish was determined by the amount of food they received and the temperature of the water together.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statements 1, 2 and 4 together.

(b) Statement 2 only.

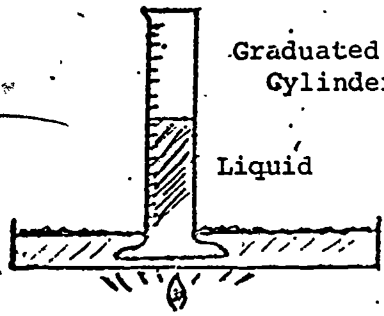
(c) Statement 1 and statement 3 together.

(d) Statement 1 only.

(e) Statement 3 only.

(f) Statement 1 and statement 2 together.

6. Thermal Expansion



Some students had noticed that when water is heated it expands (fills more space). They put different liquids one at a time into a thin graduated cylinder. Then they heated water in a pan to a measured temperature and placed the tube upright in the pan for 5 minutes.

They used an acid solution (vinegar) and a sugar solution (coca-cola) for the liquids. They heated the water in the pan first to 30°C, testing each liquid at that temperature. Then they heated the water to 60°C and tested each liquid again. Finally, they heated the water to 90°C and tested each liquid.

Here are the results.

Liquid	Temperature of Water in Pan	Volume of Cold Liquid	Volume of Heated Liquid	Increase in Volume
Vinegar	30°C	40 mL	45.0 mL	5.0
Coca-cola	30°C	40 mL	50.0 mL	10.0
Vinegar	60°C	40 mL	50.0 mL	10.0
Coca-cola	60°C	40 mL	60.0 mL	20.0
Vinegar	90°C	40 mL	55.0 mL	15.0
Coca-cola	90°C	40 mL	70.0 mL	30.0

Here are some statements about the results of the experiment.

1. Increasing the temperature of water in the pan increased the amount the liquids expanded.

2. The type of solution (sugar or acid) and the temperature to which it was heated together determined the amount of expansion.

3. The sugar solution (coca-cola) expanded more than the acid solution (vinegar).

4. The temperature of the water in the pan was affected by the type of liquid being heated and increasing the volume of that liquid.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 1 and statement 4 together.

(b) Statement 4 only.

(c) Statement 3 only.

(d) Statements 1, 2 and 3 together.

(e) Statement 1 and statement 3 together.

(f) Statement 1 only.

7. Pendulum

To study how a grandfather clock works the class made a pendulum using a weight as a bob and a string, attached to the edge of a table, for an arm. They selected 3 different strings of 10 cm, 20 cm and 30 cm in length and 3 different masses of bob (1 g, 5 g and 10 g). They measured the period (the time it takes for the pendulum to move through its swing) for each arm length and mass combination 3 times. They kept everything else, such as starting the swing at the same angle, the same for each test.

Here are their results:

Length	Mass of Bob	Period in Seconds
10 cm	1 g	.6
10 cm	5 g	.6
10 cm	10 g	.6
20 cm	1 g	1.1
20 cm	5 g	1.1
20 cm	10 g	1.1
30 cm	1 g	1.7
30 cm	5 g	1.7
30 cm	10 g	1.7

Here are some statements about the results of the experiment.

1. The period of the pendulum was determined by the length of the pendulum regardless of the mass of the bob.

2. The period of the pendulum was not affected by the mass of the bob.

3. As the length of the arm was increased there was an increase in the period of the pendulum.

4. As the mass of the bob was increased there was an increase in the length of the arm and the period of the pendulum.

Directions: Which statement or combination of statments best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 2 only.

(b) Statement 3 only.

(c) Statements 1, 2 and 3 together.

(d) Statement 2 and statement 3 together.

(e) Statement 4 only.

(f) Statement 3 and statement 4 together.

8. Heat Conduction

Bob boiled water in some pots. He used aluminum and copper pots with different thicknesses of bottoms. The same amounts of water at the same starting temperatures were set to boil on identical hot plates. He then recorded the time required for each pot of water to reach boiling point.

Here are his results:

	Time to Reach Boiling Point	
Thickness of Bottom	Copper Pots	Aluminum Pots
1 mm	5 min	6 min
2 mm	7 min	8 min
3 mm	9 min	10 min

Here are some statements about the results of the experiment.

1. If the pots have the same bottom thickness it is evident that water will boil faster in aluminum pots rather than copper pots.

2. The type of metal pot used and the thickness of the pot bottom together determine the time required to boil the water.

3. As the thicknesses of the bottoms increased the time required to boil water in them also increased.

4. The time required to boil water is less for copper than for aluminum pots.

Directions: Which statement or combination of statements best describes the results of this experiment?

Circle the letter of the best answer.

(a) Statement 3 and statement 4 together.

(b) Statement 1 only.

(c) Statement 3 only.

(d) Statement 4 only.

(e) Statement 1 and statement 4 together.

(f) Statements 2, 3 and 4 together.

9. Ramp (b) - time

George did an experiment to determine the effect of ramp height and marble mass on the length of time a marble would roll. He used marbles with masses of 1 g, 2 g and 3 g. He rolled them down a ramp 10 cm high and recorded the length of time the marble rolled. He then repeated this procedure from a ramp 20 cm high and then 30 cm high. He was careful to do everything the same each time he started a marble down the ramp.

He got these results:

	Length of Time Marble Rolled (in seconds)		
Height of Ramp	1 g marble	2 g marble	3 g marble
10 cm	2.4	4.6	6.8
20 cm	3.9	5.1	8.3
30 cm	5.4	6.[illegible]	9.8

Here are some statements about the results of this experiment.

1. As the time the marble rolled increased, the mass of the marble decreased.

2. The length of time the marble rolled was determined by both the mass of the marble and the height of the ramp.

3. As the height of the ramp was increased, the length of time the marble rolled also increased.

4. As the mass of the marble increased the length of time the marble rolled increased.

Directions: Which statement or combination of statements best describes the results of the experiment?

Circle the letter of the best answer.

(a) Statement 1 and statement 3 together.

(b) Statement 3 only.

(c) Statement 3 and statement 4 together.

(d) Statements 2, 3 and 4 together.

(e) Statement 1 only.

(f) Statement 4 only.

10. Growth of Plants - soil and water

A class is studying the effect of the type of soil and the amount of water on the growth of radish seedlings. They planted radish seeds in three pots containing sand and three similar pots containing garden soil. To one pot of sand and one pot of garden soil .01 L of water was added daily. To one pot of sand and one pot of garden soil .03 L of water was added daily. The remaining pot of sand and pot of garden soil received .05 L of water daily. They were careful to keep everything else the same for each of the seedlings. After 3 weeks they measured the height of the seedlings.

Here are the results.

Height of Seedlings After 3 Weeks

Amount of Water Given Daily	Sand	Garden Soil
.01 L	4.0 cm	6.0 cm
.03 L	6.0 cm	10.0 cm
.05 L	8.0 cm	12.0 cm

Here are some statements about the results of the experiment.

1. The amount of water given daily together with the type of soil determines the growth of the seedlings.

2. The height of the seedlings increases as the amount of water increases.

3. The plants grow taller in garden soil than in sand.

4. The type of soil is determined by both the amount of water added daily and the height of the seedlings after 3 weeks.

Directions: Which statement or combination of statements best describes the results of this experiment?

Circle the letter of the best answer.

(a) Statements 1, 2 and 3 together.

(b) Statement 2 and statement 3 together.

(c) Statement 4 only.

(d) Statement 3 only.

(e) Statement 2 and statement 4 together.

(f) Statement 2 only.

G. GENERALIZING/PREDICTING - Intermediate Level A3

Answer Sheet

	1	2	3	4
1. Pendulum	b	d	b	b
2. Coasting Distance	c	d	a	e
3. Heat Conduction	e	c	a	e
4. Thermal Expansion	d	b	a	a
5. Ramp	e	d	a	b

Note: Students must select the correct option on all 4 questions to score correct on an item.

1. Pendulum

Johnny did some experiments to find out what makes pendulums go faster and slower. He tied some string of different lengths to a nail on the edge of a table. He attached different weights to the strings. He also tried some other things but only the length of the arm (the weighted string) affected the period (the length of time taken to make one complete swing) of the pendulum.

He got the following information about arm lengths and periods.

Length of the weighted arm (his strings with weights attached)	Period of the Pendulum
10 cm	.5 seconds
15 cm	.75 seconds
20 cm	1.00 seconds

He concluded that as the length of the arm was increased the period of the pendulum also increased.

Directions: From what he had learned, Johnny might say the following things.

Circle the letter of the words that make each statement true.

1. If I did the experiment over again using the same lengths of weighted strings I would find the 15 cm arm has a period of:

   (a) approximately .5 seconds
   (b) approximately .75 seconds
   (c) approximately 1.00 seconds
   (d) approximately 2.00 seconds
   (e) approximately 1.50 seconds

2. No matter how long the period really is, the second hand of a grandfather clock moves once each time the pendulum swings and the minute hand moves ahead one minute for every 60 swings. If my clock is taking 90 seconds to move ahead one minute, I would:

   (a) make the pendulum twice as long as it is now
   (b) make the pendulum 1½ times its present length
   (c) leave the pendulum the same length as it is now
   (d) make the pendulum 2/3 as long as it is now
   (e) make the pendulum 1/2 as long as it is now.

3. Grandfather clocks use a pendulum to keep time. If I had a grandfather clock that had a 40 cm pendulum it would have a period of:

(a) 1.0 seconds

(b) 2.0 seconds

(c) 3.0 seconds

(d) 4.0 seconds

(e) 5.0 seconds

4. If I tried an experiment with a 12.5 cm weighted string the period would be:

(a) .5 seconds

(b) .625 seconds

(c) .75 seconds

(d) .875 seconds

(e) 1.0 seconds

2. Coasting Distance

Jim wondered if a person's mass has anything to do with how far he can coast on a bicycle. He asked his friends Joe, Ed and Dave, who all had the same kind of bicycles, to ride down a hill from a still start. Jim measured how far each travelled before needing to pedal to keep the bike balanced.

Here are the results:

Rider's Name	His Mass	Distance Travelled
Joe	20 kg	200 m
Ed	30 kg	300 m
Dave	40 kg	400 m

He concluded that the distance travelled increased with the mass of the rider.

Directions: From what he had learned, here are some things Jim might say.

Circle the letter of the words that make each statement true.

1. If I did the experiment over again using the same boys riding the same bikes, I would find that Ed would travel:

   (a) approximately 150 m

   (b) approximately 250 m

   (c) approximately 300 m

   (d) approximately 325 m

   (e) approximately 225 m

2. We can say that for each of the boys the distance the bike travels is:

   (a) twice as many meters as there are kilograms in his mass

   (b) half as many meters as there are kilograms in his mass

   (c) three times as many meters as there are kilograms in his mass

   (d) ten times as many meters as there are kilograms in his mass

   (e) one tenth as many meters as there are kilograms in his mass

3. If my dad, who has a mass of 75 kg, rode down the hill on one of the same bikes, I would find the distance travelled to be:

(a) 750 m

(b) 7 500 m

(c) 75 m

(d) 175 m

(e) 675 m

4. If my friend Bob, who has a mass of 5 kg more than Ed, tries the same experiment, the distance travelled would be:

(a) 325 m

(b) 375 m

(c) 275 m

(d) 340 m

(e) 350 m

3. Conduction of Heat

Roger did an experiment to find out in which kind of pots water will boil fastest. He found four flat bottom pots of the same size - two aluminum and 2 copper. One aluminum pot and one copper pot had a bottom thickness of 1 mm. The other aluminum pot and copper pot had a bottom thickness of 2 mm. Roger heated the same amounts of water, which were all the same temperature to begin with, and found the time required to heat each amount of water to 100°C.

Here are the notes that Roger kept about his experiment.

Metal Pot	Thickness of Bottom	Time Needed to Reach 100°C
Aluminum	1 mm	6 min 5 s
Aluminum	2 mm	8 min 6 s
Copper	1 mm	5 min 2 s
Copper	2 mm	7 min 6 s

He concluded that copper is a better conductor of heat than aluminum. He also concluded that the thicker the metal the more time is required to heat the liquid.

Directions: From what he had learned, here are some things Roger might say.

Circle the letter of the words that make each statement true.

1. If I repeated the experiment with a copper pot with a 3 mm thick bottom, the time required to reach 100°C would probably be:

   (a) approximately 20 min 30 s

   (b) approximately 7 min 30 s

   (c) approximately 7 min

   (d) approximately 10 min 15 s

   (e) approximately 9 min 10 s.

2. If there was twice as much water in the 1 mm copper pot as in the others, water will reach boiling point (100°C) in the least time in:

   (a) an aluminum pot with a 2 mm bottom

   (b) a copper pot with a 1 mm bottom

   (c) an aluminum pot with a 1 mm bottom

   (d) a copper pot with a 2 mm bottom

   (e) a copper pot with a 3 mm bottom.

3. I can assume that a copper pot with a bottom thickness of 1.5 mm would take:

(a) approximately 6 minutes to boil the same amount of water

(b) approximately 5 minutes to boil the same amount of water

(c) approximately 7 minutes to boil the same amount of water

(d) approximately 8 minutes to boil the same amount of water

(e) approximately 4 minutes to boil the same amount of water

4. If I had an aluminum pot with a bottom thickness of 3 mm, the time needed to boil twice as much water would probably be:

(a) approximately 10 min

(b) approximately 19 min

(c) approximately 2 min

(d) approximately 26 min

(e) approximately 20 min.

4. Thermal Expansion

Some students noticed that water expands (fills more space) when heated. They wondered if the amount of expansion is different for different liquids and if such differences are affected by the temperature to which the liquids are heated. The students put different liquids, using the same amount of each, in thin graduated cylinders. Then they heated water in a pan to a measured temperature and placed the tubes upright in the pan of water for 5 minutes. The different liquids used in the experiment were water, vinegar, and a sugar solution (pepsi-cola). They heated the water in the pan first to 30°C, testing the 3 different liquids at that temperature. The experiment was repeated putting the 3 different liquids in the pan of water heated to 90°C.

Here are the results:

Liquid	Temperature of Water in Pan	Increase in Volume
Water	30°C	4.2 mL
Water	90°C	5.5 mL
Vinegar	30°C	5.8 mL
Vinegar	90°C	7.5 mL
Pepsi-cola	30°C	8.9 mL
Pepsi-cola	90°C	11.4 mL

The students concluded that the amount of expansion of a liquid depended on the temperature to which it was heated as well as the type of liquid it was.

Directions: From what they had learned, the students who had done the experiment now said the following things.

Circle the letter of the words that make each statement true.

1. If we repeated the experiment using a new sample of vinegar of the same amount, placing it in the same graduated cylinder in a pot of 90°C water for 5 minutes, the increase in volume of the vinegar would probably be:

   (a) approximately 6.5 mL

   (b) approximately 8.3 mL

   (c) approximately 6.9 mL

   (d) approximately 7.4 mL

   (e) approximately 7.8 mL

2. If the amount of pepsi-cola we tested is about the same as there is in a bottle of pepsi, the company should leave at least:

   (a) 8 mL

   (b) 10 mL

   (c) 12 mL

   (d) 14 mL

   (e) 16 mL

   of space in the bottle to allow for expansion if the bottle is left outdoors on a hot day.

3. Vegetables cooked in water are sealed in the can at boiling temperatures. If a can of peas contains about the same amount of water as we used in our experiment, after cooling the volume would be reduced by:

(a) approximately 5.7 mL

(b) approximately 5.5 mL

(c) approximately 5.0 mL

(d) approximately 4.5 mL

(e) approximately 4.2 mL

4. If the same amount of pepsi-cola was placed in a graduated cylinder and heated in a pot of water at 60°C for 5 minutes, the increase in volume would be approximately:

(a) 10.2 mL

(b) 9.0 mL

(c) 11.0 mL

(d) 8.0 mL

(e) 12.0 mL

5. Ramp

Mary built a ramp 10 cm high and rolled a marble down it to see how far it would travel across the floor. She raised the ramp to 20 cm, and then to 30 cm and rolled the marble again each time. She was careful to do everything the same each time she started the marble down the ramp.

Here are the results:

Roll	Height of Ramp	Distance Marble Travelled
# 1	10 cm	60 cm
2	20 cm	120 cm
3	30 cm	180 cm

She concluded that the distance her marble travelled increased with the height of the ramp.

Directions: From what she had learned, here are some things Mary said.

Circle the letter of the words that make each statement true.

1. If I did the experiment over again using the same marble and a ramp height of 20 cm, the marble would travel:

   (a) approximately 10 cm

   (b) exactly 120 cm

   (c) exactly 30 cm

   (d) approximately 240 cm

   (e) approximately 120 cm

2. No matter how far the marble did travel, it is safe to say that if the ramp height is doubled or tripled then the distance the marble will travel is:

   (a) five times the ramp height

   (b) half the ramp height

   (c) increased by 10 cm

   (d) doubled or tripled

   (e) ten times the ramp height

3. If I raise the ramp height to 50 cm, then the marble will travel:

   (a) approximately 300 cm

   (b) approximately 290 cm

   (c) approximately 240 cm

   (d) approximately 50 cm

   (e) approximately 500 cm

4. If I did the experiment with a ramp height of 25 cm, I would find that the marble would travel:

(a) approximately 120 cm

(b) approximately 150 cm

(c) approximately 250 cm

(d) approximately 105 cm

(e) approximately 75 cm

GENERALIZING/PREDICTING - Intermediate Level B4

Answer Sheet

	A	B	C	D
1. Pendulum	2	2 or 3	2	3 or 4
2. Coasting Distance	4	2	1 or 2	3
3. Heat Conduction	1 or 2	4	1	3
4. Thermal Expansion	1 or 2	1	1 or 2,	4 (evaporation should also occur in that time)
5. Ramp	1 or 2	2 or 3	2 or 3	3

Note: Students must provide a reasonable rating for all 4 questions to score correct on the item.

1. Pendulum

Johnny knows grandfather clocks make use of a pendulum to keep time. Some clocks keep the right time and some run fast, others slow. Johnny did some experiments to find out what makes pendulums go faster and slower. He tied some string of different lengths to a nail on the edge of a table. He attached different weights to the strings. He also tried some other things but only the length of the arm (the weighted string) affected the period (the length of time taken to make one complete swing) of the pendulum.

He got the following information about arm lengths and periods.

Length of the weighted arm (his string with weights attached)	Period of Pendulum
10 cm	.5 seconds
15 cm	.75 seconds
20 cm	1.00 seconds

He concluded that as the length of the arm was increased the period of the pendulum also increased.

Johnny now says some things about other pendulums. Use this scale to show for each of the statements below how true you think it is:

1 = almost certainly true

2 = probably true

3 = may or may not be true

4 = not likely to be true

(a) If I used a weighted string 12.5 cm long the period would be .625 seconds. ______

(b) The period of a string 5 m long would be about 25 seconds. ______

(c) A grandfather clock with a pendulum 20 cm long would have a period of 1 second. ______

(d) A grandfather clock with a 20 cm pendulum sitting on a table that is not level would have a period of 1 second. ______

2. Coasting Distance

Jim wondered if a person's mass has anything to do with how far he can coast on a bicycle. He asked his friends Joe, Ed and Dave, who all had the same kind of bicycles, to ride down a hill from a still start. Jim measured how far each travelled before needing to pedal to keep the bike balanced.

Here are the results:

Rider's Name	His Mass	Distance Travelled
Joe	20 kg	200 m
Ed	30 kg	300 m
Dave	40 kg	400 m

He concluded that the distance travelled increased with the mass of the rider.

Jim now says some things about other situations involving coasting down hill. Use this scale to show for each of the statements below how true you think it is:

1 = almost certainly true

2 = probably true

3 = may or may not be true

4 = not likely to be true

(a) In a soap-box derby race held on Saturday, Jim notices that his big friend is in the same race as his smaller and younger brother. They are both riding in identical soap-box cars. Jim states that his brother will win. ______

(b) A fully loaded dump truck which is twice the mass of an empty dump truck will coast twice as far. ______

(c) Jim's mother, who has a mass of 35 kg, coasted down the same hill of Jim's experiment. She would travel less distance than Dave travelled. ______

(d) Jim's father, who has a mass of 75 kg, decided to coast down the hill. The experiment was done with 3-speed bikes with big tires. He used a 10-speed bike with narrow tires. From the top of the hill to the intersection and stop sign is 600 m. He will have to apply the brakes in order to stop at the intersection. ______

3. Conduction of Heat

Roger did an experiment to find out in which kind of pots water will boil fastest. He found four flat bottom pots of the same size - two aluminum and 2 copper. One aluminum pot and one copper pot have a bottom thickness of 1 mm. The other aluminum pot and copper pot have a bottom thickness of 2 mm. Roger heated the same amounts of water, which were all the same temperature to begin with, and found the time required to heat each amount of water to 100°C.

Here are the notes that Roger kept about his experiment.

Metal Pot	Thickness of Bottom	Time Needed to Reach 100°C
Aluminum	1 mm	6 min 5 s
Aluminum	2 mm	8 min 6 s
Copper	1 mm	5 min 2 s
Copper	2 mm	7 min 6 s

He concluded that copper is a better conductor of heat than aluminum. He also concluded that the thicker the metal the more time is required to heat the liquid.

Roger now says some things about other situations where heat is conducted through metal. Use this scale to show for each of the statements below how true you think it is:

1 = almost certainly true

2 = probably true

3 = may or may not be true

4 = not likely to be true

(a) Food would cook faster in a copper frying pan than an aluminum frying pan of the same thickness. ______

(b) If I put a penny and a dime on the road on a hot sunny day, the ground under the penny would get hot faster than it would under the dime. ______

(c) To conserve energy (electricity) I should cook with thin copper pots or pans. ______

(d) Water will reach the boiling point faster in a copper pot with a 5 cm thick bottom than in an aluminum pot with a 5 cm bottom. ______

4. Thermal Expansion

Some students noticed that water expands (fills more space) when heated. They wondered if the amount of expansion is different for different liquids and if such differences are affected by the temperature to which the liquids are heated. The students put different liquids, using the same amount of each, in thin graduated cylinders. Then they heated water in a pan to a measured temperature and placed the tubes upright in the pan of water for 5 minutes. The different liquids used in the experiment were water, vinegar and a sugar solution (pepsi-cola). They heated the water in the pan first to 30°C, testing the 3 different liquids at that temperature. The experiment was repeated putting the 3 different liquids in the pan of water heated to 90°C.

Here are the results:

Liquid	Temperature of Water in Pan	Increase in Volume
Water	30°C	4.2 mL
Water	90°C	5.5 mL
Vinegar	30°C	5.8 mL
Vinegar	90°C	6.5 mL
Pepsi-cola	30°C	8.9 mL
Pepsi-cola	90°C	11.4 mL

They concluded that as the temperature of the liquid increased, the volume of each liquid increased.

They now say some things about other situations where liquids are heated. Use this scale to show for each statement how true you think it is:

1 = almost certainly true

2 = probably true

3 = may or may not be true

4 = not likely to be true

(a) The increase in the volume of pepsi-cola will be approximately twice the increase in volume of a similar amount of water when they are both heated to the same temperature. ______

(b) If the same volumes of vinegar and pepsi-cola are heated to the same temperature, the pepsi-cola will occupy more space. ______

(c) If two identical capped bottles, one completely filled with water and one completely filled with pepsi-cola, are placed in the sun, the cap should pop off the bottle of pepsi-cola first. ______

(d) Suppose we fill a pail brimful with water and place it in the sun on a hot day that's about 30°C. The pail has no lid. We know it holds exactly 10 times the amount of cool water that we placed in the cylinder in our experiment. We leave it there for an hour or two to let the water heat, then put it somewhere where it can grow cool again. We should find 42 mL of water have overflowed because of expansion and the quantity in the pail is reduced by very close to that amount. ______

5. Ramp

Mary built a ramp 10 cm high and rolled a marble down it to see how far it would travel across the floor. She raised the ramp to 20 cm, and then to 30 cm and rolled the marble again each time. She was careful to do everything the same each time she started the marble down the ramp.

Here are the results:

Roll	Height of Ramp	Distance Marble Travelled
# 1	10 cm	60 cm
2	20 cm	120 cm
3	30 cm	180 cm

She concluded that the distance her marble travelled increased with the height of the ramp.

Mary now said some things about other ramps. Use this scale to show for each of the statements below how true you think it is.

1 = almost certainly true

2 = probably true

3 = may or may not be true

4 = not likely to be true

(a) There are 2 roller ramps at the Dominion Store. One is flat and one is raised. The cartons of groceries will travel farther on the raised ramp than the flat ramp. ______

(b) Suppose I had a ramp large enough for my ten-pin bowling ball and rolled the ball down it. If I make the ramp twice as high, the ball will roll twice as far. ______

(c) If the emergency brake fails on a car parked at the top of a fairly steep hill, it will travel much further than if the same thing had happened at the top of a small hill. ______

(d) I can travel much farther after reaching the bottom of a steep ski hill than one with a gentle slope even if the snow conditions are better on the smaller hill. ______