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ABSTRACT

This is one of four major subdivisions of a set of individualized evaluation material for Level I of the Intermediate Science Curriculum Study (ISCS) developed as a part of the ISCS Individualized Teacher Preparation (ITP) program. The manual contains a composite list of selected measurable objectives for Level I of the ISCS program. It is primarily a reference book for persons responsible for examining curricula and determining if this program is likely to meet their school system's objectives and needs. The listed objectives, which are divided into ten units, are designed to aid in the assessment of students who differ widely in their learning abilities and in the kinds of subject matter which they find difficult. Most units include two chapters and the related excursions. Within each unit, the objectives based on the core and the remedial excursions of the student materials are listed first, and roughly, in the order of their development in the student materials. These are followed by the objectives for the general and enrichment excursions. (Author/HM)

INTERMEDIATE
SCIENCE
CURRICULUM
STUDY

ISCS

ED178267

INDIVIDUALIZED TESTING SYSTEM

Performance Objectives
ISCS LEVEL I

SILVER BURDETT
GENERAL LEARNING CORPORATION
Morristown, New Jersey · Park Ridge, Ill. · Palo Alto · Dallas · Atlanta

INDIVIDUALIZED TESTING SYSTEM

ALL LEVELS	Individualizing Objective Testing (an ITP module) Evaluating and Reporting Progress (an ITP module)
LEVEL I	Performance Objectives, ISCS Level I Performance Checks, ISCS Level I, Forms A, B, and C Performance Assessment Resources, ISCS Level I, Parts 1 and 2
LEVEL II	Performance Objectives, ISCS Level II Performance Checks, ISCS Level II, Forms A, B, and C Performance Assessment Resources, ISCS Level II, Parts 1 and 2
LEVEL III	Performance Objectives, ISCS Level III Performance Checks, ISCS Level III, ES-WB, Forms A, B, and C WYY-IV, Forms A, B, and C IO-WU, Forms A, B, and C WW-CP, Forms A, B, and C Performance Assessment Resources, ISCS Level III, ES-WB WYY-IV IO-WU WW-CP

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FOREWORD

To implement an educational approach successfully, one must match the philosophy of evaluation with that of instruction. This is particularly true when individualization is the key element in the educational approach. Yet, as important as it is to achieve this match, the task is by no means simple for the teacher. In fact, without specific resource materials to help him, he is apt to find the task overwhelming. For this reason, ISCS has developed a set of individualized evaluation materials as part of its Individualized Teacher Preparation (ITP) program. These materials are designed to assist teachers in their transition to individualized instruction and to help them tailor their assessment of students' progress to the needs of all their students.

The two modules concerned with evaluation, *Individualizing Objective Testing* and *Evaluating and Reporting Progress*, can be used by small groups of teachers in in-service settings or by individual teachers in a local school environment. Hopefully, they will do more than give each teacher an overview of individualized evaluation. These ITP modules suggest key strategies for achieving both subjective and objective evaluation of each student's progress. And to make it easier for teachers to put such strategies into practice, ISCS has produced the associated booklets entitled *Performance Objectives, Performance Assessment Resources,* and *Performance Checks.* Using these materials, the teacher can objectively assess the student's mastery of the processes, skills, and subject matter of the ISCS program. And the teacher can obtain, at the moment when they are needed, specific suggestions for remedying the student's identified deficiencies.

If you are an ISCS teacher, selective use of these materials will guide you in developing an individualized evaluation program best suited to your own settings and thus further enhance the individualized character of your ISCS program.

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THE ISCS INDIVIDUALIZED TESTING SYSTEM

The ISCS individualized testing system for each level of ISCS is composed of four major subdivisions:

1. The ITP modules *Evaluating and Reporting Progress* and *Individualizing Objective Testing*,
2. *Performance Objectives*,
3. *Performance Checks* in three alternate forms, and
4. *Performance Assessment Resources*.

Evaluating and Reporting Progress presents a comprehensive overview, with many refinements, for individualizing the grading and reporting of students' progress, based on both subjective and objective criteria. The module *Individualizing Objective Testing* describes more specifically those ISCS evaluation materials which have objective criteria – the performance objectives, checks, and resources – and it presents practical suggestions for their use. These two modules should be considered prerequisite to successful use of the other ISCS evaluation materials.

Each of the *Performance Objectives* booklets contains a composite list of selected measurable objectives considered important to a given level of the ISCS program. However, many of the long-range goals and aims that are at the heart of the ISCS program do not lend themselves to being expressed as measurable performance objectives. Thus, these booklets should not be construed as being all-inclusive anthologies of all the possible learning outcomes of ISCS.

Each of three *Performance Checks* booklets contains an equivalent but alternative set of performance checks which were developed to assess the students' achievement of the objectives stated in the *Performance Objectives* booklets.

The *Performance Assessment Resources* booklet is a teacher's handbook to be used in identifying the appropriate performance checks with which to evaluate each student. The booklet also indicates how to set up testing situations, correct responses, and give remedial help.

NOTES TO THE READER

This book is a catalog of the ISCS objectives for Level I. It is primarily a reference book for persons responsible for examining curricula and determining if this program is likely to meet their school system's objectives and needs. As a reference book, it will also be useful to those teachers who wish to write additional objectives or performance checks.

Each objective is written in the formal style described in Excursion 2-1 of the module *Individualizing Objective Testing*. As noted in Chapter 1 of that module, each ISCS objective focuses on a specific, directly measurable student action. The objectives are, in effect, operational definitions of students' abilities; that is, they are statements of how to detect and measure what students can do.

As you might expect, ISCS has other important goals and aims that are not listed in this book. They are missing because they are generally not directly measurable given the practical confines of time and the state of the art of performance testing and measurement. In many cases, their nature is affective, rather than cognitive, and long-term as opposed to short-term. You will find many of these goals and aims discussed in the module *Rationale for Individualization*.

The objectives in this catalog are designed to aid in the assessment of students who differ widely in their learning abilities and in the kinds of subject matter which they find difficult. As stated in the module *Individualizing Objective Testing*, the key to the successful use of this catalog, the related *Performance Assessment Resources*, and the various *Performance Checks* is selectivity. This catalog of objectives was not designed so that a specific student or group of students would achieve a fixed percentage of them. Probably no one school system and certainly no one teacher will find all of the objectives in this book appropriate. As with a mail order catalog, one must pick and choose according to his needs.

The objectives listed in this book are divided into units. Most units include two chapters and the related excursions, as shown in Table 1. Within each unit, the objectives based on the core and the remedial excursions of the student materials are listed first and roughly in the order of their development in the student materials. These are followed by the objectives for the general and enrichment excursions.

LEVEL I		
UNIT	CHAPTERS	EXCURSIONS
1	1 and 2	1 thru 3
2	3 and 4	4 thru 8
3	5 thru 7	9 thru 14
4	8 and 9	15 thru 19
5	10 and 11	20 thru 22
6	12 and 13	23 thru 27
7	14 and 15	29 thru 33
8	16 and 17	34 thru 39
9	18 and 19	40 thru 44
10	20 and 21	45 thru 48

Table 1

The two types of code numbers used to identify the objectives in this book and the materials which correspond to each of the objectives in the *Performance Checks* and *Performance Assessment Resources* booklets are shown in Figure 1 below.

03	-	Core	-	17	and	05	-	Exc	19	-	2
unit		based on core material		17th objective in unit		unit		based on excursion material	excursion number		2nd objective for excursion

Figure 1

Given the following functional materials: a rechargeable battery, two test leads, and an appropriate bulb and socket, and asked to connect the materials so that the bulb lights, the student manipulates the materials to make a simple circuit so that a test lead connects one terminal of the battery to one terminal of the bulb socket, the bulb is inserted tightly into the socket, the other terminal of the bulb socket is connected to the other terminal of the battery by the second test lead, and the bulb lights by connecting the materials as described with no uncorrected errors in the process. 01-Core-1

Given a numbered diagram showing a charged cell and a bulb in a socket and asked to select numbers representing test lead connections to show how he would connect the bulb-socket to the battery to make the bulb light, the student applies the concept of a simple circuit which requires connecting one terminal of the battery to one terminal of the bulb-socket with one test lead and connecting the other terminal of the battery to the other terminal of the bulb-socket with a second test lead by selecting the numbers on the diagram to represent such connections. 01-Core-2

Given four entries which are associated with science activity and asked which entry identifies something that changes in an activity and affects the result of the activity, the student classifies something that changes in an activity and affects the results of the activity as a variable by selecting that entry. 01-Core-3

Given an assembled simple battery-bulb circuit which includes one nonoperative item, such as an uncharged battery, a burned-out bulb, or a nonoperative test lead, and the following additional items which are stated to be operative -- a bulb, two test leads, and a battery -- and asked to find out why the bulb in the assembled circuit isn't lighted, the student classifies the nonfunctioning component by substituting functioning components until the system is activated and the nonfunctioning component has been eliminated from the system by selecting the nonfunctioning component after using that method. 01-Core-4

Given three flashlight batteries, two of which are dead, two electrical devices, and three test leads and asked to find out which of the three batteries has influence, the student applies the concept that influence in a battery is tested by hooking up the battery to an electrical device that will operate if the battery has influence by reporting correctly which of the batteries has influence. 01-Core-5

01-Core-6	Given the name of an object and a task requiring the object to exert influence on another object and asked why the object must have influence exerted on it before it can perform the task, the student applies the concept that influence must be applied to an object to get influence out of it by responding to that effect.
01-Core-7	Given the terms *system, subsystem,* and *component* in one column and their definitions and a distractor in another column and asked to match the terms with their definitions, the student classifies a system as a group of objects that interact with each other, a subsystem as a group of objects that directly interact with each other within a system, and a component as an object that is part of a system by so matching the words with their definitions.
01-Core-8	Given three circuit diagrams which contain the same components, one showing the objects as individual objects and the others showing single functioning systems, and asked which diagrams represent systems and to explain his answer, the student applies the definition that a system is a group of objects which interact with each other by selecting the diagrams in which the components are assembled to interact as a system and by stating the notion of the definition.
01-Core-9	Given a metric ruler and a diagram with six labeled points and asked to measure the distance between three pairs of the points to the nearest 0.1 cm, the student manipulates a metric ruler to find the distance between each pair of points in metric units by measuring and reporting the distance between the designated pairs of points to the nearest 0.2 cm correctly in at least two of the three cases.
01-Core-10	Given the opportunity to start and observe an event of four to seven seconds duration performed by the teacher or an assistant while the audible beats of a metronome second timer can be counted and asked to time the event, the student applies the procedure for timing an event with the metronome timer by telling the teacher to start the activity on a click and then counting subsequent clicks until the teacher stops by reporting the time in seconds to the nearest whole second.
01-Core-11	Given a list of four characteristics applicable to data tables and asked to select those characteristics that determine why scientists tend to use data tables, the student recalls that data tables are used because they make finding relationships between variables easier, they tend to reduce errors by organizing data,

they provide an organized way to store data, and they help to insure that the data needed are collected by selecting either the entry "all of these" or at least three of the four other entries.

Given a completed data table as used in Chapter 2 and asked to identify three specified bits of data given in it, the student applies the procedure for locating bits of data in a data table by selecting the three bits of data. 01-Core-12

Given a list of characteristics by which an object is often defined and asked to select the characteristic which is part of an operational definition, the student recalls that an operational definition includes a procedure for measuring that which it defines by selecting the phrase "the way to measure." 01-Core-13

Given two decimal numbers and asked to find the quotient to one decimal place, the student applies the rule of division by calculating the quotient to one decimal place and by showing his work. 01-Core-14

Given two decimal numbers between 1 and 10, one of which is stated to hundredths and the other to tenths, and asked to multiply these two numbers, the student applies the rules for multiplying decimal numbers by calculating the product and correctly placing the decimal in the product and by showing his work. 01-Core-15

Given three decimal numbers in a horizontal line, two of which are stated to hundredths and the other to tenths, and asked to find the sum of these three numbers, the student applies the rules for adding decimal numbers by calculating the sum and showing his work. 01-Core-16

Given two decimal numbers in a horizontal line, one of which is stated to hundredths and the other to tenths, and asked to find the difference between these two numbers, the student applies the rules for subtracting decimal numbers by calculating the difference and showing his work. 01-Core-17

Given ample opportunity to work with materials on a laboratory activity of more than one day's duration and asked to observe the cleanup period at the appropriate time, the student chooses to close the laboratory activity period promptly upon receiving notification of the time by immediately ceasing the laboratory activity, returning materials in usable, clean condition to 01-Core-18 storage places, and participating in work area cleanup, on at least three separate occasions when being observed without his knowledge by the teacher or another designated person.

01-Core-19	When asked to work in the laboratory with fellow students, the student chooses to cooperate with fellow students in the laboratory by being polite, waiting his turn, being orderly when moving about, and observing the right of his classmates to work without being unnecessarily disturbed, when observed without his knowledge by the teacher or another designated person on at least three occasions.
01-Core-20	When asked to work with the equipment and text materials of the ISCS course, the student chooses to show personal responsibility for returning laboratory equipment no longer needed to the proper storage places during the activity period by returning such equipment and materials to the designated storage places on at least three occasions when observed by the teacher or another designated observer without his knowledge.
01-Core-21	As asked in the "Notes to the Student" section of *Probing the Natural World/1* to respond in writing to all of the questions in the text, the student chooses to write his answers in his *Student Record Book* to 90% or more of the questions in his text by exhibiting the written responses when the teacher spot checks to determine if he is doing so.
01-Core-22	When working independently in the laboratory, the student chooses to show proper care and use of ISCS laboratory materials by using the materials only for their intended purpose or by requesting permission to do other specific experiments with them, when being observed without his knowledge by the teacher or another designated person on three or more occasions.
01-Exc 01-1	Given four statements about the metric system and asked to identify an advantage of the metric system for scientific calculations, the student recalls that it is advantageous to use the metric system in science because its units are related by factors of ten and therefore changing from one unit to another is relatively simple by selecting the response to that effect.
01-Exc 01-2	Given the names of four systems of measurement and asked to identify the system used in the ISCS science course, the student identifies the metric system of measurement as the system used in the ISCS course by selecting that entry.

Given (1) a reminder that in Excursion 3 the greater of two variables, lift and drag, was found by pitting one force against the other and (2) two examples of finding the greater variable, one by direct comparison and the other by an indirect method, and asked to select the example which uses the direct comparison, the student classifies the example of direct comparison as the one in which the two forces were allowed to oppose each other directly by selecting that example. 01-Exc 03-1

Given definitions for three terms, one of which is an operational definition, and asked to select the operational definition, the student <u>applies</u> the concept that a definition is operational if it includes methods for the detection and the measurement of the entity being defined by <u>selecting</u> the definition with those characteristics. 02-Core-1

When asked whether a problem will occur if each student uses the washer scale that he made for his force measurer throughout the ISCS course and to give the reason for his response, the student <u>applies</u> the concept that the use of standard units of measurement by everyone facilitates the communication of data by <u>stating</u> that the use of washer units will cause a problem and <u>explaining</u> that the use of standard units of measurement facilitates the communication of data. 02-Core-2

Given a list of four possible alterations for a force measurer and asked to select the alterations he needs on his force measurer if he is to weigh a given object whose weight is obviously beyond its range, the student <u>applies</u> the concept that the range of an instrument can be extended by altering those features which affect its sensitivity and precision by <u>selecting</u> the entries to the effect that he would need a scale calibrated in smaller units and a thinner blade. 02-Core-3

Given a force measurer with two blades, a newton scale card, paper clips, and two objects weighing between 0.1 N and 1.0 N and asked to determine the weight of each of the objects, the student <u>manipulates</u> a force measurer to determine the weight in newtons of each of the objects by <u>reporting</u> the weight of each of the objects as determined by the teacher to within ± 0.05 N. 02-Core-4

Given a force measurer with both blades, a newton scale card, an aluminum cup, paper clips, and two objects, each weighing less than 1 newton, and asked to determine the difference between the forces (weights) they exert on the blade of a force measurer, the student <u>applies</u> the appropriate procedures for manipulating a force measurer to determine the weight of each of the two objects and of calculating the difference by <u>stating</u> the difference in newtons to within 10% of the value the teacher obtains. 02-Core-5

Given a data table indicating the increase in cumulative weight of objects of unequal mass as they are added one at a time and asked to draw a conclusion about the weights of the objects used, the student <u>applies</u> the concept that uniformly increasing the number 02-Core-6 of equal masses will uniformly increase the total weight of the group by responding to the effect that the weights of the objects are not uniform.

02-Core-7	Given a two-variable data table containing ideal data for a relationship involving direct variations and a grid with labeled axes and asked to construct a graph from the data, the student applies the procedure for plotting points from data (coordinates) and drawing the appropriate line by constructing a graph in which each point lies in a straight line and the line would, if extended, pass through the origin.
02-Core-8	When asked to define *weight* operationally, using an ISCS force measurer, the student generates the operational definition that weight deflects a force measurer blade when an object is hung on it and is measured by the amount the blade is deflected by responding to that effect.
02-Core-9	Given a force measurer, whose appropriate newton scale has been zeroed, with the blade bent a fixed amount and asked to state how much force is acting on the blade, the student manipulates the force measurer to make a correct reading on the scale by reporting an answer within ± 0.2 units of the scale.
02-Core-10	Given a force measurer with the appropriate blade attached, a hook to attach an object to the blade, a teacher-prepared scale card marked in special units, and an object to weigh and asked to find the weight of the object in the units on the special scale card, the student manipulates the force measurer scale card to zero it before weighing the object on the force measurer by adjusting the scale to zero it with the blade before weighing the object.
02-Core-11	When asked to name the metric system unit that he uses in ISCS to measure force, the student recalls the *newton* as the metric term used in ISCS science to measure force by stating the term *newton*.
02-Core-12	Given a description of a situation and asked how he can tell if a force is acting upon a specific object, the student applies the concept that a force produces a change in (1) the shape, (2) the rate of motion, and (3) the direction of motion of an object it acts upon by responding to the effect that he would look for any two of those three changes.

Given a compass and an iron object and told to bring the iron object near the compass and asked both if there is a force acting between the object and the compass and to explain the basis for his answer, the student <u>applies</u> the concept that a force changes either the motion or the shape of an object or both by <u>responding</u> that a force is in action and <u>citing</u> the motion of the needle as evidence. 02-Core-13

Given two diagrams and a description of a situation in which two identical objects are being acted upon, each by a different amount of force, and asked to determine which diagram shows the greater force acting and to explain the reason for his choice, the student <u>classifies</u> the greater of two forces as the one producing the greater amount of change in the shape of the object being acted upon by <u>selecting</u> the diagram showing the greater amount of change in shape and <u>stating</u> that a greater force will produce a greater change. 02-Core-14

When told that an operational definition answers two basic questions and asked to write an operational definition for *force* which shows how each of these questions may be answered, the student <u>applies</u> the characteristics of an operational definition to defining *force* by <u>responding</u> to the effect that a force can be detected by looking for the change in shape or motion that it causes in an object and can be measured by the amount of change in the shape or motion of that object. 02-Core-15

When asked to state the two questions answered by an operational definition, the student <u>recalls</u> that an operational definition of an entity answers the two questions about the entity, "How do I know when I have some?" and "How do I know how much I have?" by <u>responding</u> to that effect. 02-Core-16

Given a description of a situation in which weight is the force acting upon something and asked to name the force that is acting, the student <u>classifies</u> the force as weight (gravity) by so <u>responding</u>. 02-Core-17

Given a description of a situation in which weight is the force acting upon something other than a force measuring device and asked what force is acting, the student <u>classifies</u> weight as the force acting in the specified situation by so <u>responding</u>. 02-Core-18

When asked to state two reasons why it is difficult to define operationally such abstract qualities as *love*, *honor*, and *beauty*, the student <u>applies</u> the concepts that the characteristics of 02-Core-19 these abstract qualities (1) differ in each situation and (2) defy methods of detection and quantification by stating the notion of the above concepts.

02-Core-20 Given a labeled diagram of two common measuring devices, each lacking a scale, and asked to identify what both of these instruments need in order to facilitate communication of the measurements taken when using the instruments, the student applies the concept that most common measuring instruments have scales which facilitate the communication of measurements by stating that they need scales.

02-Core-21 Given a magnet, a force measurer, a thick blade, a 0-10 newton scale card, string, a nail, thumbtack, or screw, and a diagramed procedure for measuring both the weight and the strength of the magnetic force of the magnet and asked to determine the amount of magnetic force, the student applies the procedures for measuring a force as the difference between two combined forces [pulling force = (magnetic + weight force) - (weight of string + magnet)] by measuring and reporting the magnetic force, using the steps outlined.

02-Core-22 Given descriptions of five situations, three of which have a force acting in addition to gravity or friction and two of which do not have a force acting in addition to gravity or friction, and asked to identify those situations in which the additional force is present, the student classifies the situations which have a force acting in addition to gravity or friction by selecting those three situations that involve a change in shape or a change in motion not due to gravity or friction.

02-Core-23 When asked what ought to be true of an object if it is to be used as a standard for measurement, the student recalls that to be a standard unit for measurement an object must be (1) uniform over time, (2) easy to duplicate, (3) agreed upon, (4) of a convenient size, and (5) readily available by responding with the effect of at least three of those.

02-Core-24 Given a set of diagrams for the calibration of each of two uncalibrated spring scales, one set for a scale which has a reference point which varies and units which are unequally spaced and different on the two scales and a second set showing a scale on which the reference point is unvarying and the spacing between units is uniform and reproducible, and asked to select the spring scale which would be more reliable and to state the reasons for his choice, the student applies the concepts that a good measuring instrument has a stable reference point and reproducible equal unit intervals by selecting such a scale and stating the notion of the concepts.

Given that there is a need to put a scale on a measuring device and asked whether it would be best to subdivide each unit into 9, into 10, or into 11 subunits and why, the student applies the concept that subdividing a unit into 10 equal parts makes reporting and using the measurements easier than any other subdivision because of our decimal number system by responding to that effect. 02-Exc 06-1

Given three scales, one marked only in whole units, one marked in 1/2 units, and one marked in 1/10 units, and asked which of the three scales would probably give the most accurate measurement, the student applies the concept that the more subdivisions there are on a scale, the more precise are the readings that can be made with it by selecting such a scale and stating the notion of the concept. 02-Exc 06-2

Given sections of two scales, one divided into 0.1 units and the other into 0.5 units, and asked to read the scales at designated points and to report the readings as decimals, the student applies the process of reading a scale in decimal form by reporting his reading to within ± 0.05 unit on a scale marked in tenth units and to within ± 0.1 unit on a scale marked in half units. 02-Exc 06-3

Given a list of four ways in which the size of a unit of measurement might have been determined and asked to identify the entry that states the way the size of a unit of measurement is determined, the student recalls that the size of a unit of measurement is a matter of definition by man by selecting the entry involving the notion of definition by man. 02-Exc 07-1

When asked why measurement units such as the digit, cubit, and palm are not used much today and why standard units such as the meter and the gram are used, the student recalls that measurement units based on body lengths vary, whereas standard units always have the same value by responding with these two notions. 02-Exc 07-2

Given a graph of the measurement of light intensity at given distances from a lighted bulb, together with a brief description of the way the data were gathered, and the interpretive prompting that the brightness decreases as the distance increases and asked to describe the changes in light intensity when the bulb and light meter are close together and when the bulb and light meter are far apart, the student applies the rules for interpreting a graph of 02-Exc 08-1 regions of large and small changes of inversely related variables by <u>selecting</u> the words which indicate that a small change in distance produces a large change in effect at close range and a large change in distance produces a small change in effect at a distant location.

Given a description of a situation in which an object is lifted to a specified height by three different methods and asked to determine by which method the most work was done on the object, the student applies the concept that the amount of work done on an object is independent of the method used by selecting the response which indicates that the same amount of work is done regardless of the method. 03-Core-1

Given six labeled dots on a page and a metric ruler and asked to measure the distances between three pairs of points and to express the answers in meters, the student manipulates a scale calibrated in centimeters to find the distance between points in each of the three pairs by measuring and reporting that distance to ± 0.005 m. 03-Core-2

Given four distances, two expressed in centimeters and two in meters, and asked to change each distance to the unit specified, the student applies the rule that the difference between cm and m is a factor of 100 by moving the decimal point two digits to the left when changing cm to m and two digits to the right for the reverse conversion in at least three of the four cases. 03-Core-3

When asked to state the metric unit used in ISCS for measuring work, the student recalls the *newton·meter* as the metric unit used in ISCS which expresses work by naming that unit. 03-Core-4

Given instructions to select the equipment he needs to determine the amount of work done when he lifts an object from the floor and places it on his desk and asked to report in the appropriate units both the measurements he makes and the amount of work done, the student applies the definition that work is the product of a force and the distance through which it is applied by measuring the force and the distance, calculating the work, and reporting it in newton·meters to within $\pm 5\%$ of the value obtained by the teacher. 03-Core-5

When asked to state an operational definition for *work*, the student recalls that *work* is operationally defined as the product of a force and the distance through which it is applied by responding to that effect or at least to the effect that work is the product of force times distance. 03-Core-6

Given a description of a force being applied to an object over a distance and asked to state the term which best describes what is 03-Core-7 being done to the object, the student classifies the situation describing the process of exerting a force over a distance as involving *work* by stating "work."

03-Core-8	Given a list of variables, including time in seconds, speed in cm/sec, distance in cm, and force in newtons, and asked to select the appropriate information required to calculate the amount of work done on an object, the student applies the rule that force and distance are the only quantities that apply to the direct calculation of the amount of work done on an object by selecting the proper force and distance measurements.
03-Core-9	Given five definitions in one column, including one definition each for the terms *system*, *subsystem*, and *component (of a system)*, and those three terms in another column and asked to match the definitions with the terms, the student classifies a system as a group of objects that interact directly with each other, a subsystem as a group of objects that interact directly with each other within a system, and a component (of a system) as an object which is part of a system, by correctly matching each of the three terms with its definition.
03-Core-10	Given a diagram of a system with many of its components labeled and asked to list four of the labeled components that make up a subsystem, the student applies the definition that a component of a subsystem is any one of a set of objects which directly influence each other by listing any four of the labeled components which make up a subsystem.
03-Core-11	Given three diagrams, one showing components as individual objects and two showing components connected as systems, and asked which of the diagrams represent systems and why, the student applies the definition that a system is a group of objects that interact with each other by selecting the two diagrams in which the components are assembled to interact as systems and by stating the notion of the definition as the reason for his choice.
03-Core-12	Given a diagram of a system involving eight or more labeled components and a list of five sets, each containing three components of the system, and asked to identify the sets which can be considered subsystems and to state why he selected those sets as subsystems, the student applies the concept that subsystems are sets of components in a system which interact with each other directly by indicating such sets as subsystems and stating that they may be considered so because they interact directly with each other within the system.

Given a list of four phrases involving work and asked to identify the phrases which describe the relationship between work and systems, the student classifies "transfer input work" and "use input work to do useful work" as characteristics of systems by selecting those two phrases. 03-Core-13

Given a diagram and a description of a system and asked to identify the input component and the output component, the student classifies the input component as the component within a system which puts work (energy) into the system and the output component as the component which the system does work on by selecting the component that puts work (energy) into the system as the input component and the component on which work is done as the output component. 03-Core-14

Given an illustration and a description of a situation in which input work is done on some component of a system and some other component is the recipient of output work and asked to identify the input work and output work components, the student classifies what is doing work on the system as the input source and what the system is doing work on as the output recipient by indicating the source of the input work and the receiver of the output work. 03-Core-15

Given a diagram showing an equal-arm balance after it has been used to do work, the amount of input force, the distance the balance has moved, the weight upon which the work was done, and the distance the weight was moved and asked to consider the balance arm as a system and to determine the amount of input and output work done on and by the system, the student applies the concepts that input work is the work put into a system, that output work is the work done by a system, and that work is the product of the force and the distance over which the force is applied by performing the calculations on the proper quantities and reporting the input and output work done in newton·meters, correct to ± 0.1 newton·meters. 03-Core-16

Given a diagram showing an equal-arm balance, a description of a situation, and the force and the distance for the output work done by the equal-arm balance and asked to state approximately how much input work was done, the student applies the concept that work input is always greater than work output and that work equals force times distance by selecting the entry which indicates that the input work is just a little bit greater than the output work. 03-Core-17

Given a set of three decimal numbers and asked to find the average of the numbers in each set and to show his work, the student 03-Core-18 applies mathematical procedures to find an average by reporting to ±0.1 the correct response in at least one of the two cases.

03-Core-19	Given values for six measurements from an experiment and the average value of these measurements and asked to state why the average is considered to be less in error than any single measurement, the student applies the concept that the average of several measurements is probably less in error than individual measurements because the variation between individual measurements is balanced in the calculation of the average by responding to that effect.
03-Core-20	Given a description of a situation in which six to eight repeated measurements vary by small amounts and asked to explain the variation, the student applies the concept that it is impossible to eliminate all errors in measurement by so responding.
03-Core-21	Given a straight-line graph of the number of sinkers versus the mass of the sinkers in grams and asked to extrapolate and interpolate values of one variable from values of the other, the student applies the procedures for extrapolating and interpolating from a graph by reporting the coordinate values asked for to ±1 unit.
03-Core-22	Given a description of a situation in which friction is acting and heat production is evidenced and asked what force is acting, the student classifies friction as the force acting in situations involving sliding objects by naming *friction* as the active force.
03-Core-23	When asked to describe why the amount of input work done on a given system is always more than the effective output work done by that system, the student recalls the concept that some input work is used to overcome friction by responding to that effect.
03-Core-24	Given a description of a dynamic situation involving considerable sliding friction and asked what force causes the temperature change on the sliding surfaces, the student applies the concept that the force of friction causes the temperature of the sliding surfaces to change by responding with a statement to that effect.
03-Core-25	Given a description of a situation in which an object is being dragged across a surface and asked to predict what would happen to the amount of friction if weight were added to the object, the student applies the concept that the force of friction of a sliding object varies directly as the amount of weight added to it by predicting an increase in the amount of friction.

Given a description of an experimental situation in which there are two independent variables and asked to identify the error in the experimental design, the student applies the principle that there should be one and only one independent variable in an experiment by responding to that effect. 03-Core-26

Given a description of an activity involving two trials and asked to identify which variables are held constant and which are not, the student classifies a variable in which there is no change between two trials as being held constant and a variable in which there are changes between the two trials as varying by listing at least one variable for each type. 03-Core-27

Given a hypothetical situation requiring an empirical test to determine the solution to a problem and asked to identify the variable which would be varied and the factor which would vary as a result, the student classifies the independent variable and the dependent variable by naming the factor which is varied purposely and the factor which will vary as a result. 03-Core-28

Given a problem and asked to state two factors other than the independent variable which must be controlled if the results of an experiment to solve the problem is to be valid, the student applies the concept that in experimental situations there are factors other than the independent variable whose variation must be controlled if the data are to be interpretable by naming two such factors. 03-Core-29

Given a diagram of a movable pulley setup, a known mass — of which the pulley is a part — to be lifted a given distance, a set of three distance quantities including the distance the force moves, and a set of three force quantities including the approximate force required to lift the pulley and mass and asked to select the distance the force would move and the quantity of force required if the mass were to be moved a given distance, the student applies the concept that a movable pulley reduces the force necessary to lift an object, but that the force moves through a greater distance than the object moves by selecting both the force quantity which is approximately half the weight of the pulley and the mass lifted and the distance quantity which is twice the distance the mass is lifted. 03-Exc 9-1

When asked to state the relationship between the input work and the output work of movable pulley systems and the benefit, if any, of using them, the student recalls that the relationship of input 03-Exc 10-1 work to output work is about equal in movable pulley systems and that the benefit of their use is that they act as a multiplier of the input force — lifting of heavy weights with less pull required — by responding with both of those notions.

03-Exc 11-1

Given a description of a situation in which the slant of an inclined plane is decreased from the slant in a previous trial by getting a longer plane and asked the effect that a longer inclined plane has on the force required to pull or push the object up the incline and why, the student applies the concept that the force required to pull or push an object up an inclined plane decreases as the slant of the incline decreases by indicating that the force required would be less and stating the notion of the concept as the reason.

03-Exc 12-1

Given a description of a situation in which unbalanced moments exist and the magnitudes of the force and distance quantities necessary to calculate each moment and asked to determine the direction of motion and the difference in moment, the student applies the concept of differences between moments and the direction of motion for two unbalanced moments by calculating the clockwise moment and the counterclockwise moment and by finding the difference between them and the direction of rotation caused by the greater moment by responding with the results of his calculations, including both an indication that the moments are unequal in the direction of the larger moment and the amount of the moment difference.

03-Exc 13-1

Given two sets of three mixed numbers and asked to find the average of each set of numbers and to show his work, the student applies the procedure for finding an average of mixed numbers in which he adds the numbers and divides the total by the number of items in the set by reporting responses correctly to within ± 0.1 in both cases and showing his work.

03-Exc 14-1

Given a diagram of a rectangular wooden block which has three surfaces, obviously unequal in area, marked A, B, and C, a description of a situation in which the block is sequentially dragged on surfaces A, B, and C, and a set of four statements describing possible results and their reasons and asked to select the statement which best describes the result and its reason, the student applies the concept that when acting on a rectangular object, the force of friction due to weight is constant regardless of the surface area on which the weight rests by selecting the statement that supports that concept.

Given a list of four terms for kinds of energy and asked what kind of energy is given to an elastic object by compressing or stretching it, the student classifies potential energy as the kind of energy given to an elastic object by compressing or stretching it by selecting that term. 04-Core-1

Given a sentence using the term *potential energy* and asked to define the term *potential energy* as it is illustrated, the student recalls either the definition that potential energy is stored energy or the definition that it is the ability to do work by responding with either definition. 04-Core-2

Given a diagram of the same spinigig moved from the lower end of a spinigig track to the upper end of the track and a list of the following variables: the vertical heights from the floor to the spinigig at each end of the track, the diagonal distance the spinigig has moved on the track, the change in height of the spinigig, and the force needed to lift the spinigig on the track, and asked to select the force-distance pair of measurements to use for calculating the change in the potential energy of the spinigig from that at the lower end to that at the upper end of the track, the student classifies the weight-force of the spinigig and the difference in the heights of the lower and higher positions as the force-distance pair of measurements to use in calculating the change in the potential energy of the spinigig by selecting those two measurements. 04-Core-3

Given the weights of three objects and the heights in meters to which they are lifted and asked to calculate the potential energy of each object at its given height and to show his work, the student applies the rule that to calculate the gain in potential energy of an object lifted to a given height, he multiplies the weight force (in newtons) of the object by the change in height (in meters) and reports the product in newton·meters by reporting the correct values to the nearest newton·meter and showing his calculations. 04-Core-4

When asked to state whether or not there is a change in the energy of an object when it is lifted and if there is, to name the kind of energy that is given to the object or if there is not, to state why there is not, the student applies the concepts that there is a change in the energy of an object when it is lifted and that the kind of energy it is given is gravitational potential energy by responding affirmatively and stating either the term *potential energy* or the term *gravitational potential energy*. 04-Core-5

04-Core-6	When asked to name the metric unit used in ISCS for measuring gravitational potential energy, the student recalls the metric unit *newton·meter* as the unit for measuring gravitational potential energy by naming it.
04-Core-7	Given an object suspended at some height from the floor, a force measurer, an appropriate newton force scale, and a meterstick and asked to find the potential energy of the object with reference to the floor, the student applies the procedure for measuring the potential energy of an object at rest which includes measuring the distance of the object from the floor, measuring the weight force of the object, and multiplying the measurements together by reporting the calculated potential energy for the object in newton·meters within the range of $\pm5\%$ of the value determined by the teacher.
04-Core-8	Given a diagram and a description of a system and asked to identify the input component and the output component, the student classifies the input component as the object which puts work (energy) into the system and the output component as the object on which the system does work by selecting the component which does work on the system as the input component and the component on which the system does work as the output component.
04-Core-9	When asked to write a definition for the term *input work*, the student recalls the definition that input work is the work done on a system (a thing or a collection of things) by responding to that effect.
04-Core-10	Given four terms, including *energy supplier*, and asked to select the term which names the object that does work in a system, the student classifies the energy supplier in a system as the object that does work on something else by selecting the term *energy supplier*.
04-Core-11	Given four terms, including *energy receiver*, and asked to select the term which names the object in a system that has work done on it, the student classifies the energy receiver in a system as the object that has work done on it by something else by selecting the term *energy receiver*.
04-Core-12	When asked to state how he would know whether an object is in motion, the student applies the principle that an object is in motion if it can be observed changing position as time passes, if

a point on its surface appears to be moving, or if the object does work on something by stating that he would observe one of those.

Given the information that a spinigig is set up with its shaft through the skate wheel bearings and that a mass is attached to the shaft by a string which is wound up and asked to tell what effect increasing the input work would have on the speed of the spinigig as the mass falls the length of the string, provided that the number of disks is not changed, the student applies the concept that increasing the input work on a spinigig will increase the speed of rotation of the spinigig if the number of disks remains the same by responding that the speed of the spinigig will increase. 04-Core-13

Given the number of turns that an object rotates during a period of time and asked to calculate the speed of the rotation in the proper units and show his work, the student applies the rules that the number of revolutions of a turning object in a given time period is divided by the number of units of time in the time period and that the quotient is reported as the number of turns per unit of time by reporting the calculated speed in revolutions per second within the range of a 10% error. 04-Core-14

Given a grid showing plotted coordinates and exhibiting a best-fit line which curves upward to the right and asked to interpret the slope, the student applies the concept that a graph of a curved line that slopes upward to the right shows that an increase in one variable is related to an increase in the other variable but not at a constant rate by responding to that effect. 04-Core-15

When asked to name the unit used to report the speed of a rotating object, the student recalls that units for reporting the speed of a rotating object are expressed as turns -- or rotations or revolutions -- per time unit by responding with such a unit. 04-Core-16

Given a labeled grid and nine coordinate pairs for which a curved line would be the best-fit line on the grid and asked to plot the coordinate pairs and draw a best-fit line on the grid, the student applies the procedures for plotting the coordinate pairs and drawing a best-fit curved line by plotting the points and an approximate best-fit curved line that passes near or through the points. 04-Core-17

Given a grid showing plotted coordinates and exhibiting a best-fit line which curves downward to the right and asked to interpret the 04-Core-18 slope, the student applies the concept that a curved best-fit line which slopes downward to the right shows that an increase in one variable is related to a decrease in the other variable, but not at a constant rate, by responding to that effect.

04-Core-19

Given a description of a situation in which an object is rotating on its axis and asked to relate what effect increasing the mass of the object would have upon its speed of rotation if the input energy were held constant, the student applies the concept that the speed of a rotating body decreases if its mass is increased and the input energy is held constant by responding to that effect.

04-Core-20

When asked to define the term *mass*, the student recalls the definition that mass is the quantity of matter in an object by responding to that effect.

04-Core-21

Given a description of a situation in which an object gains gravitational potential energy and asked what kind of energy must be applied to the object to give it the increased gravitational potential energy, the student recalls that in certain situations kinetic, or motion, energy must be applied to an object to increase its gravitational potential energy by responding to that effect.

04-Core-22

When asked what kind of energy an object has when it is suspended, what kind of energy it has when it is falling, and what force is acting upon it to change the form of energy, the student classifies an object's energy as potential energy when the object is suspended and as motion, or kinetic, energy when the object is falling, and the force acting on the falling body as gravity, or weight, by so responding.

04-Core-23

Given a description and a diagram of a situation in which an object is lifted and allowed to drop on another object and asked to identify the supplier of input energy to the system and the receiver of the output energy from the system, the student classifies the supplier of the input energy (in this case gravitational potential energy) to the system as that agent which lifts the object and the receiver of the output energy from the system as the object upon which the energy is expended by responding with their names.

04-Core-24

When asked how he can tell how much energy there is in a moving object, the student applies the concept that the energy in a moving object can be quantified by measuring the work it does on another object by <u>responding</u> to that effect.

Given a description of the work done by a moving object, together with force and distance quantities, and asked how much motion energy the moving object has, the student <u>applies</u> the concept that the measure of a moving object's motion energy is determined by measuring the work the moving object does on some other object by <u>reporting</u> the work done to within ± 1 newton·meter.	04-Core-25
Given a labeled diagram in which some of the energy receivers and suppliers are mislabeled and asked to identify the energy suppliers and receivers which are mislabeled, the student <u>classifies</u> an energy receiver as the object upon which work is being done or whose motion is being altered by another object and an energy supplier as the object which is doing work on another object or altering its motion by <u>selecting</u> as mislabeled those for which the above definitions are reversed.	04-Core-26
Given a description of a situation in which an object is moved without loss of mass to another location where there is a decrease in the force of gravity upon the object and asked to state whether there would be any change in the mass or the weight of the object between the two locations and to state how he knew the response to give, the student <u>applies</u> the concepts that whereas the weight of an object is dependent upon its location, its mass is not, by <u>stating</u> that the mass would not change, the weight would decrease, and the essence of the two concepts.	04-Exc 15-1
When asked if an object's mass would change during a trip from the earth to the moon and to justify his response, the student <u>applies</u> the concepts that an object's mass is a measure of the amount of matter it contains and is independent of the location of the object by <u>responding</u> that the mass would not change and giving the preceding notions as the reason.	04-Exc 15-2
Given a statement reviewing the content of Excursion 17, its title, "Forerunners of Space Travel," and two sets of options and asked what each of eleven scientists had in common and what Newton meant by his statement, "If I have seen further than other men it is because I have stood on the shoulders of giants," the student <u>classifies</u> science as a creative activity productive of ideas and scientists as builders on the ideas of their predecessors by <u>selecting</u> the option in each set which agrees with one of those notions.	04-Exc 16-1

04-Exc 17-1	Given four graphs, each exhibiting a different relationship between the same two variables, and four statements of different relationships between these two variables and asked to match each graph with the statement which describes the relationship it depicts, the student classifies the relationship between variables in linear and simple curve graphs by matching each graph and the statement which describes the relationship it depicts, correctly in each case.
04-Exc 18-1	Given three graphs, each illustrating a different linear relationship between the same two variables, and a set of four statements of possible relationships of the variables and asked to match each statement with the graph which depicts the relationship described by that statement; the student classifies the three linear graphs according to the definitions that a straight-line graph with the line ascending from left to right shows that the two variables vary directly, that a straight-line graph with the line descending from left to right shows a decrease in one variable as the other variable increases, and that a straight-line graph with the line parallel to or vertical to an axis shows that an increase in one of the variables has no effect upon the other variable by matching the descriptive statements with the graphs, correctly in each case.
04-Exc 19-1	Given a description of a situation in which two objects of known mass are moving at uniform but different known speeds and asked which of the two objects has more kinetic energy, to state how much more, to show his work, and to decide which object would be more difficult to stop or would do more damage, the student applies the formula KE = 1/2 ms^2 to calculate the difference in energy between the two moving objects by showing his calculations, reporting the difference between the products within the range of $\pm 10\%$, and selecting the object which has more energy.

When asked to name the kind of energy given to an elastic object when it is stretched, the student classifies the energy acquired by a stretched elastic object as potential energy by responding "potential energy." 05-Core-1

Given a data table showing that a small force acting over a great distance may produce more work than a larger force acting over a smaller distance and asked whether it is possible that work done by a smaller force can be greater than work done by a larger force and to defend his response, the student applies the concept that because work is the product of two variables -- the force acting and the distance through which it acts -- work is dependent on the size of both variables, not just one of them, by responding positively and stating the essence of the concept. 05-Core-2

Given the initial and the final quantities of a variable force, such as those from an elastic object, and the distance through which the force acts and asked to determine the potential energy of the object, the student applies the rule that if a variable force acts through a distance, the potential energy is calculated by multiplying the average of the initial and the final force amounts by the distance through which the force acts by calculating the energy according to the formula and reporting it within the range of a 10% error. 05-Core-3

When asked to write an operational definition for *kinetic energy*, the student generates an operational definition for *kinetic energy* which includes its detection by observing movement of an object or a change in its position from a reference point and its measurement by measuring the amount of work the moving object can do on some other object by stating those notions or the formula KE = $1/2\ ms^2$. 05-Core-4

When asked for a way to tell when kinetic energy is present in a situation, the student applies the definition that kinetic energy is the energy of motion of an object by stating that its presence can be determined by observing whether or not the object has motion or changes its position. 05-Core-5

When asked how to measure the amount of kinetic energy a moving object has, the student applies the concept that the energy of a moving object can be measured by determining how much work it can do by stating that he would measure the work the object does. 05-Core-6

Given a diagram and a description of a situation in which an elastic object is (1) bent progressively through five positions to 05-Core-7 a maximum potential energy content and (2) released so as to convert the potential energy to kinetic energy and asked to identify (1) the position at which the object has the greatest amount of potential energy and (2) the position at which the object has the greatest kinetic energy after being released, the student applies the concept that the potential energy of an elastic object is greatest when the object is bent to its limit and the kinetic energy is greatest when it reaches its position of least tension upon being released from the point of greatest potential energy by selecting the position of greatest tension as the position of greatest potential energy and after release the position of least tension as the position of greatest kinetic energy.

05-Core-8	Given a diagram and a description of a situation which includes two unequal opposing forces of stated sizes and alternatives from which to select the resulting force amount and direction of movement and asked to determine the amount of net force acting and its direction, the student generates a solution to the problem of determining the amount of net force acting and its direction by selecting the statements which agree with the concepts that when two opposing forces are acting on an object, any movement will be in the direction of the larger force and its amount is determined by the difference between the two.
05-Core-9	Given a water-drop record showing the motion of a water-clock cart with the positions of the cart indicated at regular intervals and asked to select areas on the record indicating an increase, a decrease, and a constant speed as shown by a change in the distance between dots, the student classifies the intervals as follows: (1) the cart is increasing in speed when the distance between the drops increases, (2) the cart is decreasing in speed when the distance between the drops decreases, and (3) the cart is maintaining a constant speed when the distance between the drops is constant by listing the appropriate intervals.
05-Core-10	When asked to name the force that supplies the kinetic (motion) energy to a specific object when it is released on an inclined plane without being pushed, the student classifies gravity (weight) as the force which gives motion to objects that roll down inclines when they are neither pushed nor pulled by a force other than gravity by responding that the force is gravity or weight.
05-Core-11	When asked to name the force that causes a specified non-self-powered rolling object to slow down and stop without being stopped by some other object, the student classifies friction as the force that causes a non-self-powered rolling object to slow down and stop by responding that the force is friction.

Given a description of a situation in which useful output energy is less than the input energy and asked to name the force that causes this reduction of useful output energy, the student classifies friction as the force which reduces the useful output energy of an energy converter by naming friction as the force. 05-Core-12

Given a quantity of input work in newton·meters, three quantities of output work, one of which is less than, one equal to, and one greater than the input work, and three alternatives each purporting to justify the selection of a particular quantity of output work and asked to identify a possible amount of output work and his reason for choosing it, the student applies the concept that output work is always less than input work by selecting the lowest number and the statement of that concept. 05-Core-13

Given a description of a situation involving friction and asked to name the temperature change that occurs, the student applies the concept that energy used to overcome friction causes an increase in temperature by selecting the term *increase*. 05-Core-14

When asked to list six forms of energy, the student recalls forms of energy such as heat, light, electrical, potential, kinetic (motion), mechanical, chemical, sound, atomic (nuclear), and magnetic by listing at least five of those forms of energy. 05-Core-15

Given a table and a description of a situation in which a non-elastic object is lifted and dropped and asked to describe the changes in the kinds and amounts of energy that the object undergoes, the student applies the concept that an object that is lifted and dropped gains potential energy as it is lifted with kinetic energy, has maximum potential energy and no kinetic energy at its maximum height, loses potential energy and gains kinetic energy as it falls, and has no potential energy and maximum kinetic energy when it strikes the floor by selecting from the table the relative amounts of potential and kinetic energy for each description. 05-Core-16

When asked to describe a procedure for detecting and measuring light energy in some manner other than seeing the light, the student generates a procedure for detecting light energy in which a reaction caused by the light is observed in some object, such as the turning of the paddles of a radiometer or the movement of the needle of a light meter, and for measuring the intensity of light by measuring the amount of movement by stating the operations needed to get such a response to light energy. 05-Core-17

05-Core-18 When asked to identify a device which shows that light energy can do observable work and to describe how the device indicates that work is being done, the student applies the definition that work is evidenced by a change in the motion or the position of something by naming a light meter or a radiometer and stating that motion in such a light detector indicates that the light is doing work.

05-Core-19 Given a palm glass and directions for its use and asked to identify from a list of four choices the form of energy that causes the liquid to move, the student classifies heat as the energy form that causes liquid to move in a palm glass by selecting "heat."

05-Core-20 When asked to give two examples which show that electricity can be converted into kinetic energy, the student applies the concept that electrical energy can be converted into kinetic energy by stating any two instances in which electricity is used to operate an electrical device in which an object or part of it gains kinetic energy.

05-Core-21 Given a sequence of six observations in which energy is converted from potential energy to kinetic energy and back again and asked to identify the presence of energy conversions of potential to kinetic energy, of kinetic to potential energy, or the absence of conversions, the student classifies a situation as involving an energy conversion from potential to kinetic if an object gains motion because of a change of its position, from kinetic to potential if energy of motion is lost to change the position of an object so that it can release energy, or as involving neither if there is no change by so responding.

05-Core-22 Given a list of five statements purporting to be descriptive of energy and asked to identify those statements which accurately describe the characteristics of energy, the student classifies the statements "Energy can exist in more than one form," "Energy can be transferred from one system to another," and "Energy can be converted from one form to another" as characteristic of energy by selecting only those from the list.

05-Core-23 Given a diagram of a situation in which electrical energy is converted into three forms of output energy, heat, light, sound, or kinetic, and asked to name the input and output forms of energy involved, the student classifies electrical energy as the input energy form and heat, light, sound, and kinetic energy as the output energy forms by so responding.

When asked to list three energy converters found in his home and the input and output forms of energy for each, the student classifies devices involving different input and output forms of energy as energy converters by naming three devices found in the home which perform energy conversions and the input and output forms of energy for each. 05-Core-24

Given data on the dripping of a water clock on a moving cart, including the time elapsed between the first and last (N) drops to fall and the distance between drops as the cart moves, and asked to compute the speed of the cart in centimeters per second and to show his work, the student applies the rules for measuring the average linear speed of a water-clock cart by which the time interval between any two adjacent drops is calculated by dividing the time for N drops by the number of time intervals (N-1) and the time interval so obtained is then divided into the distance the cart moves between two adjacent drops by calculating and reporting the speed of the water-clock cart. 05-Exc 20-1

Given a spinigig disk, a 50 cm string, a meterstick, and a description of a situation in which an object moves around the circumference of a spinigig disk in a given number of seconds and asked to determine the average speed of the object and to show his work, the student applies the procedure for determining the speed in centimeters per second of an object around a disk in which he measures the circumference of the spinigig disk in meters to find the distance traveled (cm) and divides that distance by the time (sec) by calculating and reporting the speed within the range of a 10% error. 05-Exc 21-1

Given a description of a moving object, including its mass, its speed, and related but irrelevant data, and asked which of the variables listed are used to calculate the momentum of the object, the student classifies the speed and the mass of an object as the variables which determine momentum by selecting those variables. 05-Exc 22-1

Given a diagram showing a circuit incomplete because of an unconnected wire and asked whether or not some circuit component, such as a light bulb, a motor, or a bell, will be activated and to explain his response, the student <u>applies</u> the rule that current will not flow in an incomplete circuit by <u>responding</u> to the effect that the component will not be activated because the circuit is not complete.	06-Core-1
Given a sample of copper sulfate solution, the information that the solution is the same as the blue solution responsible for the reddish-brown coating on the carbon rod in a Chapter 12 experiment, and four alternative materials which might have been responsible for the coating and asked which of them is responsible for the coating, the student <u>recalls</u> that the blue solution he used in connection with Chapter 12 contained copper by <u>selecting</u> "copper."	06-Core-2
Given a copper-coated carbon rod and the information that it was produced as a result of the activities done in Chapter 12 and asked to identify the material that coats the rod, the student <u>identifies</u> the reddish-brown solid on the carbon rod as copper by <u>naming</u> it.	06-Core-3
Given a description of a situation in which energy is being stored in a chemical cell (a battery) and asked what energy conversion takes place in the cell, the student <u>recalls</u> that electrical energy is changed into chemical energy when a battery is charged by <u>selecting</u> the statement "Electrical energy is changed into chemical energy."	06-Core-4
Given a list of four forms of energy, one of which is chemical, and asked to select the form of energy that is stored in a battery, the student <u>recalls</u> that energy is stored in a battery as chemical energy by <u>stating</u> that the form of energy is chemical.	06-Core-5
When asked to describe what happens inside a rechargeable battery during charging and discharging, the student <u>applies</u> the concepts that charging a battery means storing energy in it by converting one substance into another and that during discharging, the reaction is reversed, releasing electrical energy, by <u>responding</u> with the essence of those notions.	06-Core-6
When asked what is required to make an electrical circuit complete, the student <u>recalls</u> that a complete electrical circuit is	06-Core-7

one which has an unbroken conductive path through which electrical current may travel by responding to that effect.

06-Core-8	Given a charged "D" size battery, two #222 bulbs and sockets, and three test leads and asked to connect the bulbs in series, using the materials given, the student applies the concept that in a series circuit, the components are connected so that the current must flow through them in succession by connecting the components in such a way that when any one of the bulbs is removed from the socket the other bulb goes out.
06-Core-9	When asked to diagram an operable circuit containing a switch, a battery, and three resistors, such as bulbs or motors, wired in series, the student applies the rule that a series circuit is wired so that the electricity follows a path from one battery terminal through the switch and each of the appliances in succession, terminating at the other battery terminal by diagraming the circuit to show that relationship.
06-Core-10	Given three descriptions, each involving two electrical devices wired either in series or parallel configuration, and a statement of the effect upon one device of the other device's ceasing to operate and asked to identify in each case whether the wiring (circuitry) between the two devices is series or parallel, the student classifies the wiring (circuitry) as series when one device's ceasing to operate causes the second device to stop operating and as parallel when one device's ceasing to operate does not affect the second device by naming each case accordingly.
06-Core-11	When asked to diagram an operable circuit containing a battery and three resistors, such as bulbs or motors, wired in parallel, the student applies the rule that a parallel circuit is wired so that the electricity flows from one terminal of the battery through each of the appliances directly and from the opposite terminal of each of the appliances back to the other battery terminal by diagraming a circuit to show that relationship.
06-Core-12	Given a charged "D" size battery, three #222 bulbs and sockets, and six test leads and asked to connect the bulbs in parallel, using the materials given, the student applies the concept that in a parallel circuit, each component is connected so that the current flowing through it need not pass through the other components in the circuit by connecting the components so that when one or two of the bulbs are removed from the sockets, such bulbs as remain stay lit.

Given a diagram of a series circuit and asked what effect adding series resistors to the circuit would have on the amount of electrical energy each circuit element receives, the student applies the principle that each resistor added to a series circuit causes every other resistor in the circuit to receive less electrical energy by responding to that effect. 06-Core-13

Given a diagram of a completed series circuit containing two resistors, such as bells, bulbs, or motors, a closed switch, and a current source and asked how to reduce the amount of current flowing, that is, to make the bulb dimmer, the student applies the rule that increasing the resistance of a series circuit by adding resistors to the circuit decreases the flow of current by stating either that he would add another resistor in series in the circuit or that he would substitute a resistor with higher resistance for one of the resistors already in the circuit. 06-Core-14

Given diagrams of two parallel circuits and two series circuits and asked to classify each circuit as either parallel or series, the student classifies the circuits as parallel if a diagram shows more than one pathway from the battery to the resistors and as series if the pathway for the electricity is shown going to each resistance consecutively by indicating the circuit type in each case. 06-Core-15

When asked why the temperature of a resistor rises when electricity is passed through it, the student applies the concept that when electrical energy passes through a material, some of that electrical energy is changed into heat energy by responding to that effect. 06-Core-16

Given a diagram and a description of a situation in which a current-carrying wire and a magnet are brought near each other and only one is free to move and asked what, if anything, will happen, the student applies the concept that there will be a force between the two objects by predicting that the object free to move will move. 06-Core-17

When asked to describe the effect on the magnetic strength of a coil of wire of varying the number of turns of wire on an electromagnet, the student applies the concept that the strength of an electromagnet varies with the number of loops on the coil of wire by so stating. 06-Core-18

06-Core-19	Given a list of four statements including "Energy can exist in more than one form" and "Energy can be transferred from one system to another" and asked to identify those statements which describe the characteristics of energy, the student classifies only those two statements as characteristics of energy by selecting them from the list.
06-Exc 23-1	Given a drawing of a battery showing two lead strips in an ammonium chloride solution and a list of materials, some of which will affect the amount of electrical energy given off by the battery, and asked to select the entries that indicate variables which will affect the amount of electrical energy given off by the battery, the student classifies the type of metal in the strip and the type of solution as the variables affecting the amount of electrical energy given off by a battery by selecting those variables.
06-Exc 24-1	Given a list of descriptions of chemical changes and asked to select the letters of the items that involve the phenomenon of stored chemical energy undergoing a change in form, the student applies the concept that chemical changes in which chemical energy is given off can be identified by the production of light, heat, electricity, bubbles, or the physical scattering of reactants by selecting descriptions of such occurrences.
06-Exc 25-1	Given three measurements made in the first instance with a simple measuring device and then with progressively more precise instruments and asked if he now knows the exact value of the measurement and to explain his answer, the student applies the concepts that all measurements, no matter how precise, are approximations and that it is impossible to eliminate errors in measurements by responding negatively and with the effect of the concepts.
06-Exc 25-2	Given a grid containing unconnected points and asked to draw the best-fit line for the points given, the student applies the concept that a best-fit line is a smooth curve with as many points above as below the line by drawing such a line on the grid.
06-Exc 26-1	Given a list of situations involving possible differences between parallel and series circuits and asked which describes a parallel circuit, the student applies the principle that parallel circuits allow the electricity to follow any one of several independent paths by selecting the response which makes that statement.
06-Exc 27-1	Given a drawing of a copper wire passing perpendicularly through a file card on which blank-faced compasses have been positioned around the wire and asked to draw the direction that the compass

needles will point if the compasses are laid at various indicated positions around the wire, the student applies the concept that the magnetic field around a wire through which electricity is flowing is a series of concentric circles by drawing the direction the compass needles will point on tracings of the blank-faced compasses shown in the problem.

Given a list of what purport to be characteristics of a scientific model and asked to select the statement which is not characteristic of a scientific model, the student recalls that a model is an explanation which establishes a relationship within a set of observations, data, or generalizations by means of a mental or physical picture or a mathematical equation by selecting the statement "It is an experimental observation" as not characteristic of a scientific model. 07-Core-1

Given a list of four purported sources of scientific models and asked to choose the correct source, the student recalls that scientific models are thought up by men by selecting that entry. 07-Core-2

When asked to state two things done by a good scientific model, the student recalls that a good scientific model (1) suggests questions, (2) explains observations, (3) suggests new experiments, and (4) predicts the nature of the results of those new experiments by responding with at least two of those four. 07-Core-3

Given four statements purporting to be characteristics of scientific models and asked to select the statement which best describes the models that scientists use, the student classifies the concept that the models scientists use may be described as useful rather than as correct by selecting the statement to that effect. 07-Core-4

When asked to name three characteristics assumed to be true of the electroparticles in the ISCS electroparticle model for electricity, the student recalls that it is assumed that electroparticles (1) can be given energy, (2) can move from place to place, (3) can give up energy, (4) will move through conductors in a complete circuit, and (5) will lose all their energy in so doing by responding with at least two of those assumptions. 07-Core-5

Given a diagram of an ISCS battery charger connected to a charging ISCS battery and asked to describe the assumed path of electroparticles and to explain the charging of the battery, using the ISCS electroparticle model, the student recalls that low energy electroparticles move out of the low energy terminal of the battery, receive energy from the charger, and return to the battery through the high energy terminal by describing the path of the electroparticles and explaining the charging of the battery as outlined above. 07-Core-6

07-Core-7	When asked whether scientists can develop more than one good model to explain the same phenomena and if so, how would a scientist decide which one to use and if not, why not, the student recalls that more than one model can be invented which can be used to explain the same phenomena and that a scientist uses the model which best suits his problem by responding affirmatively and with the notion of the concept.
07-Core-8	When asked to use the electroparticle model to describe the process of charging a battery, the student applies the assumptions of the electroparticle model to the process of charging a battery by describing the battery charging process, using the notion that the charger gives energy to the electroparticles which then return to the battery and are stored there with their extra energy.
07-Core-9	When asked to use the ISCS electroparticle model to explain how energy gets from a charged battery to a given component of an electric circuit, the student recalls that high energy electroparticles carry energy from the battery to the given component, give up their energy, and return to the battery as low energy electroparticles by responding to that effect.
07-Core-10	When asked to use the ISCS electroparticle model to describe the function of the two poles of a battery when it is connected into a complete circuit, the student recalls that outgoing high-energy electroparticles leave the battery from one pole and that returning low-energy electroparticles pass into the battery through the other pole by responding to that effect.
07-Core-11	When asked to describe what happens to the current flow when a resistor is added to a circuit and to use the electroparticle model in his response, the student recalls that the resistor allows fewer electroparticles to flow through the circuit in a given period of time by responding to that effect.
07-Core-12	Given four factors which purport to determine the number of electroparticles which pass through a resistor in a circuit in a certain period of time and asked to select the factor which determines how many electroparticles pass through the given resistor in a fixed amount of time, the student applies the feature of the electroparticle model which states that the number of electroparticles flowing through a resistor in a circuit in a given period of time is dependent upon the energy of each electroparticle by selecting the item which states that it depends upon the energy of each electroparticle.

When asked to list three phenomena of current flow which the ISCS electroparticle model does not explain, the student recalls any two of the following phenomena not explained by the electroparticle model: (1) the capacity of electroparticles to pass through solid wire, (2) the capacity of electroparticles to cause a wire to act like a magnet, (3) the ability of electroparticles to carry energy, (4) the form of the energy carried by electroparticles, and (5) the source of the energy that moves electroparticles by listing the notion of at least two of the above. 07-Core-13

When asked why an ammeter should be connected in series with a circuit, the student recalls that only in a series circuit will all of the current flowing in the circuit flow through the meter by responding to that effect. 07-Core-14

Given a diagram of an ISCS electricity measurer connected into a circuit in such a way that it is in series with the other components of the circuit and its resistor is bypassed and asked what the electricity measurer will measure, the student classifies an ISCS electricity measurer as an ammeter (or current flow meter) when its resistor is bypassed in a circuit by responding that the electricity measurer will measure current flow (amperes or electroparticles per second) passing through the circuit. 07-Core-15

Given four entries purporting to be ways by which a unit of measurement may be established and asked to identify the entry that states how the unit of measurement is determined, the student recalls that a unit of measurement is a matter of definition by selecting the entry to the effect that it is defined by man. 07-Core-16

Given the statement that one way to describe electricity is to use an electroparticle model and asked to use this model to describe the process of charging a battery, the student generates an explanation for the charging in terms of the following assumptions of the ISCS electroparticle model: the battery contains particles that (a) can be given energy, (b) can move from place to place, (c) need a completed, unbroken pathway, and (d) can be stored with the energy they received, by so describing the charging of a battery and including the notion that the charger gives energy to the electroparticles which then return to the battery and are stored there with their extra energy. 07-Core-17

When asked to name the standard unit for measuring electric current, the student recalls that the ampere is the unit for measuring electric current by responding "ampere." 07-Core-18

07-Core-19	When asked to name the standard unit used for measuring electrical energy carried by an electroparticle, the student recalls the volt as the unit for measuring the energy carried by an electroparticle by responding "volt."
07-Core-20	Given a voltmeter coil and an ISCS electricity measurer and scale set up to measure amperes and asked to make a voltmeter from them, the student manipulates an ISCS electricity measurer already set up as an ammeter so that it will measure voltage by replacing the ammeter coil with the voltmeter coil and including the resistor by disconnecting the test lead from terminal 2 and connecting it to terminal 3.
07-Core-21	Given an ISCS electricity measurer kit, four charged D-cell batteries in holders, a blank tongue depressor, five test leads, two rubber bands, and a half-kilogram mass and asked to construct a voltage scale, using the equipment furnished, the student manipulates an ISCS electricity measurer to construct a voltage scale by assembling the equipment with the zero point marked on the tongue depressor when no cells are in the circuit, making additional points on the scale at the resting points when each additional cell is added in a series with the first cell, and then labeling the marked points above the zero as 1.5, 3.0, 4.5, and 6.0 volts in sequence.
07-Core-22	Given diagrams of a completed series circuit and a completed parallel circuit, the materials to construct the circuits, and an electricity measurer (or ammeter) to measure the current flow and asked to construct the circuits and measure the current flow, the student applies the rule that ammeters are connected in series with the current supply and the total resistance and the rule for measuring current flow by connecting the ammeter correctly in each circuit and reporting both of the ampere readings within one of the smallest subdivisions on the scale.
07-Core-23	Given a diagram and a description of a situation in which the pointer of an electricity measurer deflects the wrong way and asked how to reverse the direction of deflection of the pointer, the student applies the principle that the direction of deflection of the pointer can be reversed on a meter of that type by reversing the connections of the meter to the circuit by responding to the effect that he would reverse the connections of the meter to the circuit.
07-Core-24	Given a diagram of a series circuit and asked what effect adding resistors in series to the circuit will have on the amount of electrical energy each circuit element receives, the student

applies the principle that each resistor added to a series circuit causes every element in the circuit to receive less electrical energy by stating in effect that less electrical energy is received by each element.

Given a description of a situation in which a wave passes under an object floating on the open ocean and four statements describing the motion of the object and asked to select the statement which best describes the motion of the object in the water, the student applies the principle that when waves pass through water, the surface water does not move the object horizontally but moves it up and down by selecting the statement to that effect. 07-Exc 28-1

Given a trough, water, a cork, a pencil, and instructions for wave-making and asked if the cork-water system moves horizontally toward or away from the wave source or does not move horizontally at all and what, if anything, moves across the surface of the tank, the student applies the concept that it is energy which moves horizontally in a wave and not the medium itself by responding that there is no horizontal movement of the cork-water system and with the essence of the notion that energy is transported horizontally. 07-Exc 28-2

Given a description of a situation in which two theories apply, an older, more restricted one and a newer, broader one, and the statement that the restricted theory is used in a specific situation and asked whether or not the newer theory should be used instead and to explain his answer, the student applies the principle that any description is a good model if it explains the observations and can be used for the purpose intended by responding negatively and stating the notion of the principle. 07-Exc 28-3

Given a scientific model and a series of statements each purporting to be a criterion that scientists would have for accepting this model and asked to select the criterion by which models are judged, the student applies the concept that new models and constructs are proposed as useful ways of thinking about phenomena by selecting the response to the effect that they are accepted if they constitute useful ways of thinking about phenomena. 07-Exc 29-1

Given that a model is accepted by most scientists and five interpretations of what it means for a model to be accepted by most scientists and asked to select the best interpretation, the student applies the concept that scientific acceptance of a model implies that it explains the observations made to date but does not imply that scientists feel either that it represents an absolute truth or that no other model would work by selecting the 07-Exc 29-2 entry involving explanation of observations, but not those entries implying the model to be an absolute truth.

07-Exc 29-3	Given the information that a particular model is accepted by most scientists and four alternatives which purport to be interpretations of what it means for a model to be accepted by most scientists and asked to select the best interpretation, the student applies the idea that a model needs to be modified to account for new observations by selecting the entry that best states the idea.
07-Exc 30-1	Given two diagrams, each showing two wires suspended parallel to and close to each other and connected into separate but equivalent battery-switch circuits, differing only in that one diagram shows the positions of the two wires when the switch is open and the other when it is closed and a statement of the terminal from which the electroparticles flow out of and back into one of the batteries and asked to indicate from which terminal the electroparticles flow from the other battery and through which terminal they return to the battery responsible for the attraction or repulsion shown, the student applies the concept that an attracting force exists between two parallel wires carrying electricity in the same direction and that a repelling force exists between two parallel wires carrying electricity in opposite directions by indicating that when the parallel wires repel each other, the electroparticles leave and reenter the battery so that they are going in different directions in the parallel wires and when the wires attract each other, the electroparticles leave and reenter the battery so that they are going in the same directions in the parallel wires.
07-Exc 31-1	Given statements describing possible behavior patterns of scientists as a group and asked which is the best description, the student applies the principle that scientists, like other human beings, exhibit a variety of behavior patterns by selecting the statement to that effect.
07-Exc 32-1	Given a description of how long or how fast two battery-operated toys work and asked to indicate whether or not the toys' batteries are connected in series or in parallel and to explain his choice, using the electroparticle model, the student applies the concepts that in a series circuit an electroparticle picks up energy from each battery through which it flows, thus enabling the toy to run faster but for less time than if it were in parallel circuit, whereas in a parallel circuit electroparticles are furnished by each battery independently, causing the toy to run more slowly but for greater lengths of time than if it were in a series circuit by responding with the notions of the concepts.

Given a description of the number of batteries and the number of resistors in a parallel circuit in a toy and asked in what way a change in the number of resistors and the number of batteries would change a voltmeter reading taken in the circuit and to explain his answer, using the electroparticle model, the student applies the electroparticle model to determine that when added in parallel, more batteries do not affect how much energy an electroparticle in the circuit carries by stating that with an increase in the number of batteries, the voltmeter reading would remain the same. 07-Exc 33-1

Given a description of the number of batteries, the number of resistors, and the type of circuit (series) in a toy and asked in what way a change in the number of equivalent resistors and the number of batteries would change an ammeter reading taken in the circuit and to explain his answer, using the electroparticle model, the student applies the electroparticle model to determine that in a series circuit, more batteries connected in series give the electroparticles more energy, resulting in more current through the resistors, and that an increase in the number of resistors connected in series decreases the current in the circuit by responding that when the same number of equivalent resistors and batteries are added to a circuit, the ammeter reading should stay the same. 07-Exc 33-2

Given the statement that an ammeter must be connected in series rather than in parallel with a circuit to measure the flow of current and asked to use the electroparticle model to explain why the ammeter is connected in series, the student applies the assumption of the electroparticle model that an ammeter counts all the electroparticles flowing through the circuit by responding with the function of an ammeter and that only when the ammeter is connected in series will all electroparticles pass through the ammeter. 08-Core-1

When asked how a voltmeter should be connected to a component to measure the voltage available to the component, the student recalls that a voltmeter should be connected in parallel with the circuit component to measure the voltage available to it by responding to that effect. 08-Core-2

Given a diagram of a series circuit involving one device, a resistor, a switch, and a battery with all terminal connections identified by letter and asked to describe the procedures to use in this situation to detect and measure the voltage across the named device, using such additional apparatus as necessary, the student applies the procedures to detect voltage -- (1) connects the terminals of an electricity measurer (voltmeter) to the two terminals of the device and (2) notes whether the meter pointer moves when current is flowing in the circuit, which is the sign that there is voltage -- and the procedure to measure voltage -- reads the voltmeter scale pointer (if the pointer moves down instead of up, he reverses the leads connecting the voltmeter with the device) -- by so responding and indicating the connections. 08-Core-3

Given a diagram of a complete circuit containing two electrical meters, one connected in parallel with the circuit and the other connected in series with the circuit, and asked to designate each of the meters as either a voltmeter or an ammeter and to tell how each is connected to the circuit (in parallel or in series), the student identifies the electricity measurer (meter) connected in series as an ammeter and the electricity measurer (meter) connected in parallel as a voltmeter by selecting the function of the meter and the type of circuitry with which they are connected to the main circuit. 08-Core-4

Given the ammeter reading in amperes, the voltmeter reading in volts, and the time in seconds that a light bulb receives energy and asked to calculate and report the energy received by the bulb, the student applies the formula that electrical energy equals amperes times volts times time by calculating the energy given to the light bulb and expressing the answer in newton·meters. 08-Core-5

08-Core-6 Given four formulas involving current, voltage, and time, one of which is the formula for calculating electrical energy in a direct current circuit, and asked to identify the formula for calculating electrical energy, the student classifies volts times amperes times time as the formula for calculating electrical energy by selecting it.

08-Core-7 When asked to name the three variables he measures in order to determine the total amount of electrical energy delivered to some component of a complete circuit, the student recalls that the variables measured to determine the total amount of electrical energy delivered to a circuit component are current (or amperes), battery voltage (or volts), and time (or seconds) the current flows by stating those variables.

08-Core-8 Given an electricity measurer, voltage and amperage scales, a timer, two test leads, and a prewired circuit in which a battery supplies electricity to operate two electrical devices connected in parallel and asked to measure the energy supplied to one device for fifteen seconds and to show his measurements and calculations, the student applies the rules for connecting a voltmeter across the terminals of the electrical device, connecting an ammeter in series with one of the devices, measuring the voltage, amperage, and time, and calculating the energy, using the formula voltage times amperes times time equals electrical energy by reporting the measurements and the calculations within the range of ±1 newton·meter.

08-Core-9 When asked to state two reasons that scientists prefer to make observations in terms of quantities, the student recalls that numerical information aids in precise, unambiguous communication and analysis by responding with both of those notions.

08-Core-10 Given a list of five operating electrical devices and asked to indicate those in which electricity produces observable work, the student classifies the situations in which there is evidence of a force being applied through a distance because of the application of electrical energy as situations in which electricity does observable work by selecting such examples.

08-Core-11 Given a voltmeter (electricity measurer), diagrams of both a parallel circuit and a series circuit, and the equipment to construct the circuits and asked to construct each circuit, measure and report its voltage across the entire circuit, and show the setup to his teacher, the student applies the rule that the voltmeter is connected in parallel to the circuits and the rule for measuring the voltage by installing the meter correctly in each circuit and by reporting the voltage across each circuit correctly to within ±1 volt.

Given descriptions and diagrams of a completed series circuit and a completed parallel circuit, each having a battery and four resistors, and asked to explain why the series circuit has greater resistance than the parallel circuit, the student applies the concepts that the current must flow through all the resistors in the series circuit, whereas the current in the parallel circuit can flow directly and independently through each one of the resistors by responding to that effect. 08-Core-12

Given diagrams of a completed series circuit and a completed parallel circuit, each consisting of a battery and four resistors, and asked in the case of the series circuit whether the current flows through each resistor by a separate path or in sequence and whether the total resistance to current flow is less or greater than that in the parallel circuit, the student classifies a multiple-resistor circuit wired in series as one in which the current flows through each resistor sequentially and in which the total resistance is greater than in a parallel hookup of the same components by selecting the alternatives that agree with those concepts. 08-Core-13

Given a labeled diagram of an electric motor mounted to lift sinkers and asked to propose a procedure for using the equipment shown to define operationally the electrical energy of a battery, the student generates a procedure for detecting the energy of a battery by observing the work it does and for measuring that energy by determining the amount of work it does in the given system by stating an operational definition which includes detecting energy by the movement of the sinkers and measuring either (1) the total distance that the battery (motor) lifts a fixed number of sinkers before it stops lifting or (2) the number of sinkers the battery (motor) can lift a specified distance. 08-Core-14

Given a model for the transfer of energy from one location to another, using canned goods to represent energy, and a list of variables in the model's operation and asked to choose from the list of variables the element of the model which corresponds to a volt, the element which corresponds to an ampere, and the element which corresponds to an electroparticle, the student classifies a volt as corresponding to the number of cans a person could carry at one time, an ampere as corresponding to the number of cans being put down in each time unit, and an electroparticle 08-Exc 34-1 as corresponding to the number of persons available to move the cans by matching those elements of the model with those terms.

08-Exc 35-1	Given a list of variables that may or may not affect the power available to a light bulb and asked to choose the variables which are factors in determining the flow of electrical power, the student applies the principle that electrical power is a function of the voltage and the current by selecting the appropriate entries.
08-Exc 35-2	Given 2 electricity measurers (a voltmeter and an ammeter), 1 switch, 3 bulbs, 2 motors, 1 ISCS battery, 7 test leads, and a diagram of a completed series circuit involving the battery which operates one or more of the bulbs and motors and asked to set up the circuit shown and to calculate the power by taking the necessary current and voltage measurements, the student applies the rules that voltmeters are connected in parallel to the circuit, that ammeters are connected in series to the circuit, and that power is the product of voltage times amperage by measuring the appropriate voltage to within ± 1 volt and the amperage to within ± 0.2 amperes and calculating the power correctly from his measurements.
08-Exc 36-1	Given the resistance, the voltage, and the current along a wire in one toy and asked what the resistance of the same kind, size, and length of wire will be in another toy that is identical except that it has more batteries operating it and therefore higher voltage and current and to explain his answer in terms of the electroparticle model, the student applies the principle that the resistance of wires of the same kind, size, and length is the same by responding that the number of electroparticles passing through the wire increases and the energy of each electroparticle also increases, causing no change in the voltage-current ratio.
08-Exc 37-1	Given a motor in working condition, one magnet with the N-pole upright and the other magnet with the S-pole upright, and asked to predict what will happen if one magnet is turned upside down and to explain his prediction, the student applies the principle that one magnet's N-pole and one magnet's S-pole (or one taped end and one untaped end) must be positioned near the coils to attract and repel the motor arm so that it is under constant magnetic force which causes it to revolve by responding that changing one of the magnets will cause it to repel the arm coming toward it and attract the arm going away from it and thus slow down or stop the motor.
08-Exc 38-1	Given a picture and a description of a motor-driven toy and asked to describe what measurements he would need to make in order to

determine how much work the motor in the toy will do, the student applies the principle that work is calculated by multiplying force times the distance the force is applied by responding that he would make measurements of force and distance.

Given the following statements: "You have learned about electricity from activities like the ones in your text without too much trouble. It was the explorers who had a hard time," and access to Excursion 39 and asked what he has that the explorers didn't have that makes his task easier, the student identifies as factors which make his task easier than that of the explorers activities that have been pretested to be sure they are safe, safety tips, experimental designs written out for him, equipment that is available, models that have been suggested, and the accumulated body of scientific knowledge by stating the notion of at least one of those factors. 08-Exc 39-1

Given an air piston and asked to fill it with a certain amount of water, the student manipulates the piston in such a way as to fill it with the specified amount of water by inserting the tip of the piston into the water and moving the plunger so that its front edge is on the specified mark (±0.1 unit) and the chamber is completely filled with water and contains no air bubbles. 09-Core-1

Given a 6.0 cc air piston partly filled with liquid and asked how much liquid the syringe contains, the student manipulates the air piston to read its scale by reporting the volume of the liquid accurately to within ±0.1 cc. 09-Core-2

Given a list of four changes in a substance, one of which is that an increase in volume is coincident with a temperature increase, and asked to select the usual result of increasing the temperature of a substance, the student recalls that an increase in volume is coincident with a temperature increase by selecting the statement to that effect. 09-Core-3

Given that a device is needed to measure a very small change in temperature and yet provide easily distinguishable readings and a list of four materials, including a solid, a liquid, and a gas, and asked which of the substances is best to use in such a device, the student applies the concept that a gas has a greater increase in volume when heated than does a solid or a liquid by selecting the gas as the best expanding substance for the device. 09-Core-4

Given a diagram showing the locations of the freezing point of water on both a Fahrenheit and a Celsius thermometer and asked to explain why the freezing point of water can be both 32° and 0°, the student applies the concept that it is possible to have different scales based on different definitions to measure the same phenomenon by responding to that effect. 09-Core-5

Given a story in which two people make measurements in body-part units and disagree about whose measurement is correct and asked what needs to be done to avoid future confusion, the student applies the rule that to be standard, the units of measurement have to be agreed upon by responding to the effect that a standard or an agreed-upon unit is necessary. 09-Core-6

When asked what unit is used by scientists and in ISCS for measuring temperature, the student recalls the degree Celsius as the standard unit used in ISCS for measuring temperature by naming that unit. 09-Core-7

09-Core-8	Given a picture of a thermometer marked in degrees Celsius and asked what happens to water when its temperature registers 0°C and 100°C, the student recalls that at 0°C water freezes and at 100°C water boils by stating those facts.
09-Core-9	Given a thermometer calibrated in Celsius units and asked to measure the temperature of a substance, the student manipulates the thermometer to find the temperature of the substance by reporting a reading on the scale of the thermometer within an accuracy of ±1.0 scale interval.
09-Core-10	When asked how a thermometer which contains a liquid confined in a tube works, the student recalls that the liquid expands as temperature increases and contracts as temperature decreases by responding to that effect.
09-Core-11	When asked to explain why putting a jar with a lid stuck on it into hot water will sometimes cause the lid to loosen, the student generates an explanation based on the concepts that most substances expand when heated and that different substances expand at different rates by responding to the effect that the hot water heats the lid and causes it to expand faster than the jar, which loosens it.
09-Core-12	When asked to give an operational definition for the change in the heat content of liquid water when the temperature change is known, the student recalls that an operational definition for the change in the heat content (energy) of liquid water includes multiplying the mass of the water in grams by the number of degrees Celsius that its temperature changes by responding to that effect.
09-Core-13	Given a known mass of water and the degrees Celsius that the temperature of the water is raised in a given period of time and asked to calculate the number of calories of heat required to raise the mass that many degrees, the student applies the rule that the number of calories required to raise a mass of water a given number of degrees Celsius is equal to the product of the mass of water in grams times the number of degrees Celsius the mass is raised by correctly reporting the product in calories.
09-Core-14	Given a list of four temperatures in degrees Celsius and the information that a given mass of water is heated for a given period of time and asked to predict what the temperature will be if the mass is reduced by half but the time and the rate of heating remain constant, the student applies the concept that given a fixed amount of heat, the temperature of water varies

inversely with the amount of water being heated or that the total heat in calories of a substance is equal to its mass in grams times the change in temperature expressed in degrees Celsius by selecting the response that represents that relationship.

When asked what a thermometer measures, the student recalls that a thermometer measures temperature by responding to that effect. 09-Core-15

Given a list of terms associated with heat and temperature measurement and asked to choose the standard unit used in ISCS for measuring heat, the student recalls that the unit in which heat is measured in ISCS is the calorie by selecting that choice. 09-Core-16

Given a description of a model for heat which assumes that heat is a substance which can flow between objects and that its quantity determines the temperature of objects and asked to name two observable properties of heat that are in agreement with the model, the student classifies as two observable properties of heat in agreement with the assumptions of the heat-substance model that heat can be transferred from one object to another and that matter expands when heated and contracts when cooled by responding with the effect of both of those properties. 09-Core-17

Given an illustration indicating that heat flows from a burner and passes through a glass beaker into water which heats a test tube full of water which then expands and a list of eight purported characteristics of heat particle properties and behaviors and asked to select the four characteristics that are compatible with the heat-substance model, the student classifies as the characteristics of heat compatible with the heat-substance model that the substance must (1) take up space, (2) have mass, (3) be made up of tiny particles, and (4) be able to move by selecting those four characteristics and no others. 09-Core-18

Given a description of a situation in which the model for heat as a substance flowing from hot objects to cold is challenged by the suggestion that there exists a cold substance which flows from cold objects to cool off a hot object and asked to defeat the challenge, the student generates the argument (1) that if it were cold that was transferred, the object containing this cold substance would be expected to contract as the cold substance flowed out of it and the object got warm, and the object receiving the cold substance would expand as it got cooler and the cold substance flowed into it or (2) that the object containing the cold substance would be expected to lose weight as it got warmer by responding with either of those arguments. 09-Core-19

09-Core-20	Given that three pieces of the same kind of metal are equal in size and mass and asked to predict the effects on the objects if one is cooled, one is heated, and one remains at room temperature, the student applies the rule that metals usually expand when heated and contract when cooled by selecting the entry that is in agreement with the following: the heated object will expand, the cooled object will contract, and the one remaining at room temperature will remain unchanged.
09-Exc 40-1	Given a list of characteristics relative to the boiling and freezing points of liquids and asked which characteristics are inappropriate for a liquid which is to be used in a thermometer to measure water temperature, the student applies the principle that the liquid used in a thermometer should not have a boiling or freezing point in the temperature range in which he wishes to make his measurements by selecting the choices which agree with that notion.
09-Exc 41-1	Given diagrams of both Fahrenheit and Celsius thermometers and asked if a temperature drop of X degrees has the same meaning in degrees Celsius as in degrees Fahrenheit, the student applies the principles that there are more unit intervals between the freezing and the boiling temperatures of water on the Fahrenheit scale than on the Celsius scale and that an X degree drop on the Celsius scale is greater than an X degree drop on the Fahrenheit scale by responding with the effect of those principles.
09-Exc 42-1	When asked to define *calorie* in terms of water, the student recalls the definition that a calorie is the amount of heat it takes to raise the temperature of 1 gram of water 1° Celsius by responding to that effect.
09-Exc 43-1	When asked at which temperature, hot or cold, his system will need to supply more calories to maintain normal body temperature and to explain his answer, the student applies the principle that the body needs to supply more calories to maintain normal body temperature when the temperature of the environment is lower by responding to that effect.
09-Exc 44-1	Given that a fixed amount of heat is added to a fixed amount of four given substances whose specific heats are stated and asked which of those would show the greatest temperature change, the student classifies the substance having the lowest specific heat as undergoing the greatest temperature change by selecting that substance.

Given a diagram and a description of a situation in which four containers of varying temperatures are placed in contact with each other and asked to indicate the direction of heat flow, the student applies the rule that heat flows from hot to cold objects by indicating that heat flows from containers of relatively high temperature into adjacent containers of lower temperature in all such cases. 10-Core-1

Given a description of a situation in which four containers of water, all of equal size but whose temperatures vary, are placed in contact with each other in an insulated box and asked to predict the temperature of the water after equilibrium is reached, the student applies the rules that heat flows from hot to cold materials until equilibrium is reached and that equilibrium temperatures may be calculated by adding the water temperatures of the containers and dividing by the total number of containers by selecting the response to that effect. 10-Core-2

Given five entries, including the three states of matter, and asked to choose the state which is likely to be the poorest conductor of heat for a given substance, the student recalls that the gaseous state of a given substance is the poorest conductor of heat by selecting it. 10-Core-3

Given a diagram of three beakers, one containing a metallic solid, one a liquid, and one a gas, all receiving equal heat and having thermometers placed in contact with the materials at equal distances from the heat source, and asked in which of the three cases the thermometer will show a change in temperature first and for what reason, the student applies the concept that, in general, metallic solids are better conductors of heat than liquid or gaseous materials by selecting the beaker containing the metallic solid and stating the essence of the rule. 10-Core-4

Given as a criticism of the procedures of Activities 20-7 and 20-8 that the balance is so crude that small increases in the mass of the water cannot be detected and asked to state a way to detect such increases in mass, the student generates the suggestion that a more delicate balance be obtained or that a larger mass be heated so that more of the heat substance will be present and therefore can be more easily detected by stating the effect of one of those notions. 10-Core-5

Given a description of a situation in which one of two objects of equal mass is heated, a drawing of an ISCS equal-arm balance with one of the masses attached to each arm, equidistant from the pivot point, and a list of four possible balance positions and asked to 10-Core-6 predict the position of the balance arm after one of the masses is heated, the student applies the rule that the mass of an object remains unchanged by heating by selecting the response which indicates that the position of the arm does not change as a result of heating the mass.

10-Core-7	Given two theories -- one restricted and one broader -- applied to a situation and the statement that the restricted theory is used to work a specific set of problems and asked if the broader theory should be applied to the situation instead and to explain his answer, the student applies the concept that a model is suitable to a specific situation if it explains the observations and can be used for the purpose intended by responding negatively and stating the notion of the concept.
10-Core-8	Given a list of four possible sources of scientific models and asked to identify the origin of scientific models, the student recalls that scientific models are thought up by people by selecting the entry reflecting that notion.
10-Core-9	Given four statements about the heat-as-energy model and asked to select the best statement about the model, the student applies the concept that scientific models are best described as useful explanations and as the bases for predictions by selecting the statement that agrees with that concept.
10-Core-10	Given that the heat-as-energy model is accepted by most scientists and five interpretations of what it means for a model to be accepted by scientists and asked to select the best interpretation, the student applies the concept that scientific acceptance of a model implies that it explains the observations made to date, but does not imply that scientists feel that this model is an exact representation of reality or that no other model would suffice by selecting the interpretation involving explanation of observations, but not those implying the model to be absolute.
10-Core-11	Given data about how many observations each of two models for heat can explain and asked to identify the better model, the student applies the rule that the better of two models is the one which explains more related phenomena by selecting heat-as-energy as the better model and stating the notion of the rule.
10-Core-12	Given a diagram and a description of a situation in which an object expands when heated and asked to explain the expansion of the object, using the heat-substance model, the student applies the notion that heat substance itself takes up space and forces

the particles of matter in the material being heated to move farther apart, thereby increasing the volume of the material, by stating the essence of that notion.

Given a diagram and a description of a situation in which an object expands when heated and asked to explain the expansion of the object, using the heat-as-energy model, the student applies the concept that objects increase in volume when they are heated because the heat supplied to the particles of matter causes the particles to vibrate faster, causing them to move farther apart and occupy more space, by stating the essence of the notion. 10-Core-13

Given directions to touch two things before and after rubbing them together vigorously and asked to predict how long the observed effect will continue if he continues to rub them together and to explain his prediction in terms of the heat-as-energy model, the student applies the heat-as-energy model to the rubbing of two objects by predicting that the objects will continue to heat up as long as they are rubbed together and stating that rubbing causes the particles in the objects to vibrate faster as long as the rubbing continues. 10-Core-14

Given a line representing a range of energy levels and asked to locate states of matter on the line according to their relative energy levels, the student applies the concept that for a given substance, the gaseous state has more energy than the liquid state and the liquid state has more energy than the solid state by indicating the relative positions of the three states on the line. 10-Core-15

Given a statement that there is more heat in a large quantity of cool water than in a small quantity of hot water and asked to explain why this is true, using the heat-as-energy model, the student generates the explanation that the amount of heat stored is the total amount of particle vibration and that in the large quantity of cold water so many particles vibrate that although they are vibrating more slowly than in the small amount of hot water, the total amount of vibration is greater by responding with the essence of the notion. 10-Core-16

When asked to use the heat-as-energy model to explain how a thermometer works, the student applies the heat-as-energy model to explain the rising and falling of the liquid in the thermometer by responding that when a thermometer is placed in hot materials, energy of motion is absorbed (transferred) from the moving particles of the substance whose temperature is being measured, causing the liquid particles of the thermometer to move faster and therefore farther apart, and that when a thermometer is placed in cold 10-Core-17 materials, the particles give up energy to the material being measured and vibrate less, thereby becoming closer together and occupying less space, which reduces the volume of the liquid.

10-Core-18	Given data in graph form showing the input-output of a machine which has a constant amount of energy supplied to it and showing the output work plotted against the temperature change of the machine and asked to explain what is happening to the input energy as the amount of useful energy decreases, the student generates the explanation that the increase in temperature is the reason for the decrease in usable output energy because the machine converts more input energy into heat energy and less into output energy as the temperature of the machine increases by responding to that effect.
10-Core-19	Given a diagram and a description of an activity in which input energy is greater than output energy and asked to explain the missing energy in terms of the heat-as-energy model, the student applies the concept that the missing energy is converted by friction into heat energy, or particle vibrations, in sliding surfaces by stating the essence of that concept.
10-Exc 45-1	Given a description of bunk bed sleeping accommodations and a heating element on or near the floor and asked in which bunk he would be most likely to keep warm and to explain his answer, the student applies the principle that warm air has more volume per unit of mass than a corresponding mass of cooler air by responding that he will be warmer in the top bunk and with the principle that the warm air has more volume per unit of mass and will rise, whereas the cooler air will sink.
10-Exc 46-1	Given four statements purporting to be reasons to discard a scientific model and asked when a scientific model is discarded, the student applies the principle that scientific models are discarded when new, well-tested observations are made that do not fit the model, that is, when the modification of the model begins to cause internal contradictions, by selecting the entry to that effect.
10-Exc 47-1	Given a temperature-time graph showing changes in the state of matter and asked to describe what is occurring during each time interval represented by each section of the line of the graph, the student applies the concepts that during cooling the curve slopes downward to the right or that during heating the curve slopes upward to the right and that during changes of state the slope is zero by so responding.

Given three time-temperature graphs and asked to choose the graph that best represents the cooling of a pure substance through a change of state, the student applies the principles that cooling curves have a negative slope and that during a phase change there is no change in the temperature of a pure substance by selecting a curve which best fits the notion for a cooling situation. 10-Exc 47-2

Given a description of a sequence in which energy is converted from one type to another and asked if all the energy has been converted to the type of energy described at the end of the sequence and if not, where the lost energy goes or the gained energy comes from, the student applies the rules that energy conversion always involves a loss of usable energy, that the total amount of energy is never altered, and that some of the input energy is converted to heat energy by responding that the apparently lost energy has been converted into heat energy. 10-Exc 48-1