SYSTEM ASSIGNMENT OF LEARNING STRATEGIES IN A COMPUTER SIMULATION OF AN IMAGINARY SCIENCE

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The rapid technological advancements over the last 10 years has spawned a growing anticipation of what the future holds in store. Instructional approaches of the past are being overshadowed by an almost frenzied interest in the utilization of the micro-computer in education. There seems to be a common interest in the creation of a program which will take advantage of the computer's capabilities in providing access to a wealth of information and yet be easy for the student to communicate with, while allowing for a variety of learning strategies. It is apparent with the phenomenal advances of computer technology over the last few years that the limitations of this ideal information system will not be in the technology. The attainment of this goal will necessarily require a more thorough understanding of the learning process, especially in terms of the strategies that successful learners employ.

McConkie (1978) has stated that learning is a function of "...the task structure, the strategies adopted by the person to deal with the task, and the persons own skills and abilities" (p. 71). The purpose of this current research is to explore the effects that these strategies can have in a sophisticated computer simulation. More specifically, this study investigated the effectiveness of attempting to direct the strategies employed by learners in a computer simulation of an artificial science, to determine whether learners select effective strategies when left alone, or if they require assistance in the selection of the strategy from the "system." Furthermore, the nature of system assignment of learning strategies was explored to discover whether learners perform as well when the computer system gives directions on which strategy to employ as when the strategy is built into the instructional system.

Instructional research has typically focused on the task structure and the strategies that are part of the instructional approach adopted by the designer, with little interest in the potential interaction of task or method with the skills or abilities of the learner (Resnick, 1981). Generally speaking, the strategies that learners tend to use when given various instructional tasks have been neglected. The implication of this neglect can be severe,

> by not stressing learning strategies, educators, in essence discourage students from developing and exploring new strategies, and, in so doing limit students' awareness of their cognitive capabilities (Dansereau, 1978, p. 2).

The challenge is one of developing the usefulness of the technology while allowing for the greatest flexibility in terms of the way that learners can make use of the resources that are provided to them. The problem goes beyond one of making software that is "user friendly." It is necessary to provide some guidance in the best way to approach the instructional task without restricting the freedom of the learner in making use of their own proven "cognitive capabilities."

LEARNING STRATEGIES

Rigney (1978) described learning strategies in terms of two elements: "(a) a cognitive orienting task, and (b) one or more representational, selectional, or self-directional capabilities." These elements can be thought of as; the way that particular learning strategies are selected, and the various kinds of strategies to select from, respectively. The next major section will describe what Rigney has called "orienting tasks" followed by a description of the "processing resources" for cognitive learning strategies.

ORIENTING TASKS

Orienting tasks are deliberate attempts to induce the learner to employ particular strategies. As Rigney states "Although cognitive strategies are always performed by the student, initiation of their use may come from the student's self-instructions or from an instructional system". This led to the notion of the "control of orienting tasks" where he makes the distinction between student assigned (SA) and instructional system assigned (ISA) orienting tasks. Student assigned orienting tasks are essentially the selection of particular strategies based on the students own determination of the best approach to handle specific tasks. Little is known at this point about the ability of learners to select appropriate strategies, although there is evidence to suggest that learners vary their use of strategies with different task demands (Bruning, 1982). Instructional system assigned orienting tasks are attempts made by the designer to build certain strategies into the instruction, or direct the learner to use a particular strategy. Implied by the notion of instructional design is the selection of the most effective strategy by the designer which then guides the development of the method used in the instruction.

Another dimension useful in describing learning strategies, which is separate from the idea of selection, deals with the location or source of the strategy. Rigney calls this dimension the "explicitness of cognitive strategy" and makes the distinction between "embedded" and "detached" strategies.

Embedded Strategies

Embedded strategies are basically the design strategies incorporated into the instruction which handle the processing normally required by the learner in learning a given task. This means that the instructional designer develops the instruction such that the selected strategy is "built in." For example; including diagrams in abstract material helps to represent the information in a graphic form, thus providing an image that learners would most likely have trouble forming on their own. Most instruction is based on the notion that the responsibility for learning lies with the instruction, consequently the strategy is typically embedded. This is consistent with the attention given to the task structure rather than to the possible interaction between task and the abilities or strategies employed by the learner. It is assumed that the strategies selected by the designer will be the most appropriate for the task and the abilities of the learner, when in fact the selection is most likely based upon the designer's own preferred learning strategies with little regard for the learner's abilities or preferences. An additional concern is that what is given to the learner and how it is presented may be less important than how the individual learner makes use of what is given to them.

Detached Strategies

Detached strategies are the processing strategies that the learner uses in connection with the instruction. Using the imagery example above, many learners who have a preference for representing problems visually will, for instance, draw a diagram of an algebra story problem in order to "see" how the pieces fit together. Often such strategies are used without conscious awareness on the part of the student and, in many cases, the strategies selected may be inappropriate for the task. However, it is very possible that what has not been accounted for in the past are the detached strategies employed by successful learners. It is reasonable to assume that what makes successful learners better than unsuccessful learners is not solely the instruction, or even necessarily aptitude, but rather the interaction between the two, where aptitudes may be represented as the selection of effective learning strategies. In fact, it is probable that effective detached strategies are responsible for high achiever's success in spite of the instruction. The example of algebra story problems represents the difficulty in providing minimal strategy direction, where the successful learner is one who has developed an effective strategy on their own.

The Explicitness / Control Matrix

The relationship between the two dimensions of "explicitness of cognitive strategy" and "control of orienting task" is shown below as a matrix;

Explicitness of Cognitive Strategy	Control of Orienting Task	
	SA	ISA
Detached	A	B
Embedded	C	D

Figure 1 Alternative approaches to teaching and using cognitive strategies (Rigney, 1978).

Each cell in the matrix represents a different approach in dealing with learning strategies.

Cell "D" (Instructional System Assigned - Embedded) represents the traditional form of instruction where cognitive strategies are incorporated into the design of the instruction itself. Most designers attempt to build in what they consider to be the most effective strategy for learning a particular task. However, Rigney notes that "Not all instructional strategies ... are designed to induce students to use cognitive strategies." Many instructional strategies merely organize or sequence the information to be given in a manner consistent with the structure of the task, without consideration of the cognitive processing which might result. For instance, a procedural task is generally ordered so that each step of the procedure to be learned is covered in turn, which is fine, except that the order of presentation generally represents the entire strategy. The strategy could be developed further to break the procedural steps into actions and objects to be manipulated. This would provide the learner with a more thorough analysis of the important elements which could help them learn more effectively. This additional processing would be left to the learner in the "order only" strategy.

Cell "A" (Student Assigned - Detached) represents the situation where no attempt is made by the instruction to induce any particular cognitive strategy, leaving the selection and control with the individual learner. By not addressing the strategies which could be employed by learners in a given situation, the instructional designer is leaving learners on their own.

Cell "C" (Student Assigned - Embedded) represents the unique condition where the learner may select from a number of embedded strategies. A good example of this form of instruction is the "TICCIT" systems. TICCIT stands for "Time-shared, Interactive, Computer-Controlled, Information Television" (Merrill, Schneider and Fletcher, 1980). TICCIT differs from other forms of computer-aided instruction, in that it has the instructional strategies built into the design of the system. Another major difference with TICCIT is the degree to which learners can control the sequence and type of displays presented to them. These unique characteristics allow the learner to select between various forms of embedded strategies.

Of primary interest to this study is cell B, which represents the attempt, on the part of the designer, to direct the detached processing of the student. This is of interest for basically two reasons; first, if subjects can be directed to utilize certain strategies then the effectiveness of those strategies may be assessed by comparing the learning outcomes with outcomes from other strategies, and secondly, if directions to employ a specific strategy is as effective as embedding the strategy into the instruction then the development and revision of instruction may be enhanced by simply attaching processing directions (see Callahan & Merrill, 1979).

If the most effective strategy for a given task can be identified, and the strategy can be elicited by providing directions to the learner, then the goal of providing easy access to information while allowing for variation in learning strategies can be achieved while developing the skills needed to get the most from the technology.

Forms of Orienting Tasks

One of the most critical features of a study of learning strategies is the method used to elicit the appropriate strategy in the learner. These "orienting tasks" are meant to elicit the appropriate processing in the learner whether student or system assigned. There are two forms of orienting tasks. The first form; instructions, are given prior to the unit of instruction to direct the learner to process in a certain way. A serious drawback to this approach is that simply instructing the learner to use a particular strategy does not guarantee that the intended processing will occur.

> This form of orienting task (instructions) exerts fairly weak control over the desired cognitive processing operations (Rigney, 1978).

> The second form of orienting tasks are direct questions.

> As orienting tasks for cognitive strategies, they (questions) must be designed to require that desired kinds of processing resources be used in order to answer them (p. 195).

This "inquisitory" approach provides a much more useful system assigned orienting task than merely telling the student which strategy to employ at the beginning of the unit. Studies of the effects of such questions on learning have shown that inserted questions can improve performance on a variety of tasks (see Glaser & Resnick, 1972 and Andre, 1979 for reviews of this literature). The results of this research has also indicated that the effects of questions have two components;

> (a) direct instructive effects, that is, questions are informative; and (b) general, attention-like effects, that is, effects on the inspection (studying) behavior of the student (Rothkopf & Bisbicos, 1967).

An extension of this approach is what Rigney calls "self-generated questions":

> There is a great current interest in question-answering instructional systems, in which students also can ask questions of the system. The thought is that this will allow students to pursue their curiosity about a topic, acquiring answers to questions they really want to have answered ... Self-generated questions may be among the most potent orienting tasks, driving learners to search for answers they want to know (p. 199).

Frase & Schwartz (1975) have shown that having subjects generate and answer their own questions improves recall with prose beyond directions to just study. Clearly then, the most powerful instructional system is one which provides access to the necessary information but which allows the learner to ask questions of the system. The form of these questions ought to use natural language for requests of factual information, a requirement which involves considerable effort and sophisticated programing, or of a "what if" nature where the learner varies certain conditions and then sees the result of the changes. The later form is more useful when dealing with conceptual or rule using tasks, where there are relationships between variables or attributes.

PROCESSING RESOURCES

One of the most difficult problems facing research on learning strategies is finding a useful way of classifying the range of possible processes which may influence performance on a wide range of tasks. Before we can investigate the effects of directing learning strategies, it is necessary to determine what kinds of strategies may affect learning outcomes. Typically the notion of learning strategies is confused with such terms as; cognitive processes, cognitive strategies, information processing strategies, etc. Consequently, it is difficult to sort out the differences between these forms of cognitive operations and what is meant by learning strategies. To compound the problem, much of the cognitive psychology research follows experimental paradigms utilizing word lists or paired associate learning. These tasks, while providing more finite control, do not sufficiently represent the natural environment to allow us to generalize. Furthermore, the "strategies" dealt with generally relate almost exclusively to short-term memory and can be seen as "micro-strategies" in that they represent components of the more general strategies likely to be under instructional control.

Rigney provided an outline of the "processing resources" for cognitive strategies in three categories; representational, selectional, and self-directional processes. These global "processes" represent the general strategies most likely to be under the influence of the instructional researcher and provide more concrete prescriptions of treatments.

Representational Processes

There are basically only two general ways to represent information; verbally and graphically. Therefore the two representational tools which can affect learning strategies are language and imagery. Of the two, language has been typically overemphasized in education, mainly because most instruction uses a verbal rather than a graphic medium. Text is simply easier and more economical to produce than visuals, especially visual images that provide motion. A strategy which has received considerable attention recently, deals with the use of imagery to aid in the recall of prose. Many successful learners utilize imagery as a detached strategy to augment instructional tasks. In one of the first in a series of studies of the effectiveness of imagery in learning from text, Anderson & Hidde (1971) found that "...people instructed to form images of the events described in sentences recalled more than three times as many words on a surprise test as people who merely pronounced the sentences" (p. 527). It seems logical that graphically represented information may prove to be an essential characteristic of an instructional system designed to study learning strategies.

Selectional Processes

The first of the two selectional processes described by Rigney is simple selective attention. Knowing where and how to access information may be more important than being able to recall the information directly. Attention also relates to the ability to deal with distraction, or the ability to concentrate.

> The stream of consciousness may be less a stream than a bubbling caldron where all sorts of odds and ends continually surface to interfere with the task of learning (p. 197).

This implies that some form of "attribute isolation" would be an important consideration. Attribute isolation is the method of focusing the attention of the learner on specific characteristics or attributes of the task in order to reduce distraction from surrounding detail. For example, underlined or boldfaced words draw attention to the more important information in text. In the same manner, certain attributes of a complicated visual computer display can be isolated by enlarging the target image or by simply blacking out all unrelated information.

The second selectional process; intention, involves the notion of self-discipline. "The analysis and generation of goal structures might also be taught to students to assist them in controlling their intentions to learn" (p. 198). This process would involve breaking the overall task into smaller more manageable goals. Learners typically try to absorb too much information at one time. Thorndike and Statsz (1980) found that a difference between good and poor learners performance in learning from maps was that good learner's behaviors were goal-directed. Meaning that the more successful learners took more manageable parts of the task as sub-goals, allowing them to spend their time in the most efficient manner. Many learners are not successful because they basically do not know how to manage their time effectively.

Self-directional Processes

One of the important self-directional skills; self-programming relates to the matching of processing resources to learning task requirements by the learner. In other words, this form of self-direction involves the selection of the appropriate strategy by the learner for a given task.

> Learning self-programming ... would be equivalent to learning self-assignment of different orienting tasks as subject-matter characteristics changed (p. 200).

The notion of self-programming is a major issue in this research; do learners have the necessary skills to select the most efficient strategy for a given task?

The second self-directional skill; self-monitoring, functions to "...identify errors, to keep track of progress, to sense processing overload, and to monitor the performance of actions" (Thorndike and Statsz, 1980). A major difference between what were considered "good" map learners and "poor" ones were the good learners ability to accurately evaluate their learning progress, and to focus attention on unlearned information. It seems that, even though the poor learners typically had more unlearned information to choose from, they focused a smaller proportion of attention on unlearned information than good learners. This implies that they spent a larger amount of their time confirming information that they already knew. Presumably, one of the advantages of an embedded approach, especially in a computer-based treatment, is the ability to keep track of the progress of the learner allowing for more effective time management.

STRATEGY TRAINING

Some of the most recent research on learning strategies involved the training of general cognitive strategies. Dansereau (1978) described a learning strategy training program which taught subjects in three different study techniques; 1) paraphrasing, the process of re-stating the information in different terms, 2) question-answering, involving the generation of questions and the answers, and 3) the use of visual imagery, where the information is represented in some meaningful visual form. The results indicated that subjects trained in the use of these study strategies performed better on a measure of long-term retention than untrained subjects who studied the same materials. Weinstein (1978) described the effects of "elaboration skills training" on reading comprehension. Elaboration skills training involved practice in the generation of a variety of mnemonic devices for a section of prose material. These mnemonic or memory devices required the learner to further process the information by representing the facts in ways which tied them together to aid in retrieval. Results on a delayed post test revealed significant differences between the subjects who received training and the control group.

It seems quite reasonable that learners would require training in the creative techniques described by these two researchers. These skills would not generally develop without some form of instruction. The strategies of interest in the current study were those techniques described previously, involving selectional and self-directional processes. It was felt that these skills reflected individual aptitudes and represented strategies developed by learners on their own. In addition, the strategies dealt with in the current research involved more of a problem solving skill than the recall and retention of specific information which was taught in the Dansereau and Weinstein studies.

It was hypothesized that the system assignment of learning strategies in a complex problem solving task would be more effective than leaving subjects to assign their own idiosyncratic strategies, and that detached would be equally as effective as embedded system assigned strategies.

RELATED RESEARCH

Callahan and Merrill (1979) studied the effect of what they called "compensating cognitive strategies" on impoverished instructional materials in a concept classification task. Subjects were given directions on various strategies that were designed to compensate for "lean" instruction. They found that subjects directed to use a classification strategy performed better on a post test that did controls.

A study by Bruning (1982) explored the use of "conscious cognitive strategies" in a wide range of task and content types. Findings indicated that subjects vary strategy use as a function of task demands. A factor analysis of the questionnaire used showed three underlying factors; overt practice strategies, clustering strategies, and mnemonic strategies. Of the three, clustering strategies were preferred with mnemonic strategies least preferred.

Most recently, a study was conducted to explore the effects of system assignment of learning strategies on the acquisition of concepts (Allen, 1982). This study utilized a micro-computer based research tool using an artificial science. There were no significant differences found between treatments which were designed to compare two strategies in learning coordinate concepts. However, it was concluded that the relatively large amount of error variance was due, in part, to the use of continuation students as subjects.

These studies represent a beginning in the attempt at directing the use of specific learning strategies. The present study extends this research by focusing on the more complex rule using behavior and by comparing the detached and embedded treatment of the same strategy. In addition, a sophisticated computer simulation was developed in connection with this study which provides substantial control over treatment implementation and, in essence, epitomizes the question-answering instructional system referred to by Rigney (p. 199).

METHOD

SUBJECTS

The 63 subjects in this study were enrolled in 2 "Computer Literacy" and 2 "Computer Math" courses taught by two different teachers in a Southern California high school. Forty-seven of the subjects were in the 12th grade, 8 were in the 11th grade, and 8 were in the 10th grade. Thirty-six of the students were male and 27 were female. The classes were selected because of the willingness of the high school administration and the individual teachers to participate, and because of the micro-computer lab used by the two courses met the requirements of the computer software used. The two Computer Literacy courses met the first two periods and the Computer Math courses met periods 3 and 6. The four classes in the study had 15, 16, 17, and 15 students participating, respectively.

INSTRUCTIONAL TREATMENT

The instructional treatment used in this study consisted of an imaginary science simulation called "Xenograde". Xenograde (pronounced zen'-o-grade) is a micro-computer simulation developed by the author, which is based upon the "Xenograde Systems" utilized by Merrill (1965). A Xenograde System is an imaginary molecule, consisting of two basic parts; a nucleus, and orbiting satellites.

"Alphons" are small particles that may reside in the nucleus or in the satellites.

The alphons within the nucleus are constantly moving between the inner (center) section and outer (shell) of the nucleus. This movement within the nucleus is explained by the "breathing principle." A Xenograde system is "inhaling" when the alphons are "migrating" from the outer shell to the center section of the nucleus. Conversely, the system is "exhaling" when alphons migrate from the center to the outer shell. The breathing "phase" changes when the migration is completed. For instance; when all of the alphons have migrated into the center of the nucleus, the breathing phase will change to exhale and they will begin migrating back to the outer shell. The breathing principle provides one of the more fundamental rules of the science, which allows the prediction of the number of alphons in either section of the nucleus after a given number of "alphon seconds". An alphon second is arbitrarily defined as the length of time for one alphon to travel from one section of the nucleus to the other. For example; if there were 5 alphons on the outer shell of the nucleus, and the system was currently inhaling, there would be 2 alphons remaining on the outer shell after 3 alphon seconds had elapsed, since 1 alphon would have migrated to the center section each second. With no interaction between the satellites and the nucleus, the number of alphons in the nucleus will remain constant. This constant is called the Xenograde Number.

Somewhat independent of the movement of alphons within the nucleus, the satellites are in constant orbital movement around the nucleus. The satellite orbit is a bit unusual,. however, in that the tangential or circular movement around the nucleus remains fixed while the velocity relative to the nucleus varies. In other words, the only aspect of movement of a satellite that is of interest to the science is the absolute distance of the satellite from the nucleus. The position of the satellite, in terms of it's 360 degree rotation about the nucleus, is ignored. This movement toward the nucleus causes the satellites to periodically collide and subsequently "rebound", changing it's direction relative to the nucleus, and begin movement away. The contact is reference by a "blip" which represents the exact time (in tenths of a second) when contact was made. The satellite undergoes a similar change of direction when it reaches the maximum orbit and "reflects" back toward the nucleus. The velocity (V) of the orbiting satellites (relative to the nucleus only) is a function of the charge (C) of the satellite (the number of alphons it is carrying) and a system constant (K) where $V = C * K$. This movement of the satellites provides another rule of the science which allows predictions of satellite position similar to the predictions regarding alphon movement within the nucleus. This prediction, however, is a bit more complex since it can involve real number, or fractional, distances. The predictions involving movement of alphons involve integers, or whole numbers, only. The added complexity is due, in part, to the fact that the calculation of the distance a satellite travels may require the solution to include a collision with the nucleus, or a reflection from the maximum orbit, which may occur between seconds. As a result, the calculation may involve fractions of seconds.

The system enters a third level of complexity when alphons are exchanged between satellites and the nucleus during a collision. The rules which govern whether a satellite will pick up or drop off alphons are related to the breathing phase. If the system is exhaling, and a satellite collides with the nucleus, alphons will be picked up from the outer shell of the nucleus. Alternately, if the system is currently inhaling during a blip (collision with the nucleus), then the satellite will drop off alphons to the outer shell. The number of alphons exchanged is determined by the number available and certain constraints imposed by the system. For instance; if a blip occurs during exhale phase, all of the alphons available on the outer shell, at the time the blip occurred, will be picked up by the satellite. Conversely, during inhale phase, all of the alphons carried by the bliping satellite will be dropped off to the outer shell, effectively reducing the charge, and consequently the velocity, of the satellite to 0. There are maximum limits, however, which affect the number actually exchanged. The maximum number of alphons that a satellite can carry is 12. The maximum number of alphons that the nucleus can hold is 9. The number actually exchanged is based upon the number available and whether the satellite or nucleus has sufficient space to hold the additional alphons. For example; if a satellite with a charge of 4 (carrying 4 alphons) collides during inhale phase with the nucleus which is currently holding 6 alphons, only 3 of the 4 that are carried by the satellite will be dropped off since the nucleus can only add 3 more before reaching it's maximum capacity of 9. This interaction between the satellites and the nucleus makes predicting the location of alphons and the position of satellites considerably more complex. As an illustration, it is frequently the case that the satellite velocity for the first fraction of a second will be different than the remaining fraction of a second after exchanging alphons. This is because the velocity is a function of the new charge, which resulted from the change in the number of alphons carried by the satellite.

Xenograde

The Xenograde program simulates various monitoring devices which keep track of the constantly changing conditions of a Xenograde system. The monitoring devices represent the activity graphically and numerically, using sound to draw attention to significant changes. The simulator display is updated each alphon second to provide an ongoing picture of the system dynamics. Figure 2 shows the complete simulator display. There are basically five major divisions of the screen.

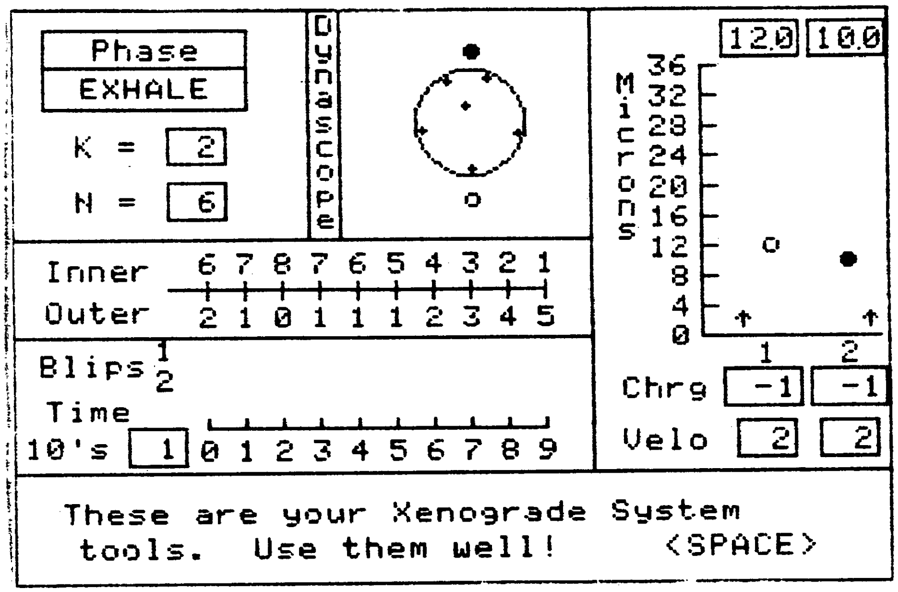

Figure 2 Xenograde Simulator Display.

1. The "Dynascope," located in the top center of the display, provides a picture of the molecule in operation. Each second the Dynascope shows the new position of each alphon in the nucleus and position of the satellites relative to the nucleus.

2. The "Phase indicator," located in the upper left, displays the breathing phase (INHALE or EXHALE) that the system is currently in. Just below the Phase indicator are the Xenograde constant (K) and the Xenograde number (N) indicators.

3. Below the Dynascope is an indicator which tracks the number of alphons in each section (Inner and Outer) of the nucleus. The

indicator displays 10 consecutive seconds before clearing.

4. The "Blip indicator," located in the lower left portion of the display, displays the time line, the number of 10's of seconds that have elapsed, and the specific time that each blip occurs (displayed as a number above the appropriate position on the line).

5. The right portion of the display tracks the conditions of the satellites. This section displays the distance of each satellite from the nucleus in graph form, as well as the actual number displayed at the top. The arrows at the bottom of the graph indicate the direction that the satellites are moving relative to the nucleus. The charge (Chrg) and velocity (Velo) of each satellite are also displayed directly beneath the graph.

Finally, the bottom section of the screen is used for displaying directions, menu options, and other information.

The basic approach behind the simulation was that of an exploratory tool. The goal was to use these monitoring devices to explore the operation of the mysterious molecule and to try to understand the rules which govern it's actions. The learner would be challenged to demonstrate their understanding by successfully predicting specific changes in the state of the molecule over brief periods of time. There are 31 specific behavioral objectives of the

Xenograde curriculum (see Appendix A), ranging from simple facts to complex rules involving the interaction of system elements, and covering nearly all of the unique predictions that are possible for the given system.

The "What If?" Option

An optional feature of the simulator was designed to provide the essential question-answer capability, described by Rigney, which would allow the learner the freedom to ask questions that would be most meaningful for them and thereby accommodate variable learning strategies. In order to provide the mechanism for the kind of freedom which was sought, a "what-if" paradigm was adopted. This allowed the learner to control the molecule's actions by changing specific conditions. For instance, the learner could ask, "what happens when the satellite hits the nucleus?" To answer this question, the learner "sets the stage" by stopping the simulator, positioning the satellite so that it is nearing the nucleus, and then watcheing as the satellite makes contact. As soon as contact is made, the learner may want to freeze the action and study the situation in order to determine what changes took place. Stopping and starting the simulator is as easy as pressing the "RETURN" key. Changing system conditions is accomplished by first pressing the space bar causing a "scrolling" menu to appear in the bottom window with the first option highlighted. Pressing the space bar again will cause the first option to "scroll" up with the next option taking it's place in the highlight. Continued pressing of the space bar will cause each successive option to scroll past until all 9 options have appeared, at which point the list will repeat itself. When the desired option is located in the highlighted line, pressing the RETURN key will cause the bottom window to clear and the selected option's current value will be displayed, along with a prompt to input a new value, with the range of allowable values shown in square brackets ([]). After a number within the allowable range is entered, the simulator returns to operation after changing the requested parameter to the new value. The complete list of conditions that can be changed are;

Option	Description
System Constant - K	Value of K
INHALE Phase	Set Phase to INHALE
EXHALE Phase	Set Phase to EXHALE
Inner Nucleus	Number of alphons in the inner section
Outer Nucleus	Number of alphons in the outer section
Satellite 1 Charge	Charge of Satellite 1
Satellite 2 Charge	Charge of Satellite 2
Distance 1	Distance of Satellite 1 from the nucleus
Distance 2	Distance of Satellite 2 from the nucleus

With these options the learner can modify the simulation to set up most every condition imaginable. This "What If" feature is the essential element in the treatments which allowed the learner to control the simulator.

TREATMENTS

Each subject, regardless of treatment group, was given an introductory segment on the computer which explained the essential nature of the science and the measuring devices provided by the simulator. Appendix B shows the 25 displays that present the necessary instruction. Many of the displays are dynamic in that they actively demonstrate the operation of the devices as they are explained. The pacing of display presentation is under learner control by pressing the space bar when they are ready to continue. However, since they could only advance to the next display, they were only allowed to view each display once. The average time to complete the introductory segment was approximately 25 minutes.

Treatment 1 represents the Student Assigned (SA) condition where the student was not given any directions regarding learning strategies, receiving the basic simulator with the What If option described previously. With the controls available, the subjects could explore the science on their own by applying whatever strategy they selected. Accompanying the program was a page of instructions on how to operate the simulation (see Appendix C).

Treatment 2 represents the Instructional System Assigned (ISA) Detached condition and involved the same basic simulator, only in addition to the operating instructions the subject's handout included instructions which described, in general terms, the recommended approach they were to follow (see Appendix C). The handout contained 12 general questions, each representing a category of the objectives, such that all 31 objectives could be generated from the set. The basic premise was that given the general format, the subjects would generate the specific conditions for the actual questions themselves. This allowed them the freedom to generate their own instances, or their own questions if they desired, in learning the operating characteristics of the Xenograde molecule.

Treatment 3 represents the Instructional System Assigned (ISA) Embedded condition which followed a "built-in" strategy. This strategy presented various situations and asked the subject to predict the status of the system after a specified length of time. The program was a special modified version of the simulation which provided a fixed question/answer/feedback strategy. Each question represented one of the objectives and were ordered in terms of complexity with the more elementary objectives first. Each objective had at least one remedial question. If the subject answered a question incorrectly they were given the remedial question. However, if they answered correctly the remedial question was skipped. In either case the subject was given detailed feedback regarding their answer, followed by a demonstration of exactly what would have occurred under the specified conditions. This provided direct practice with the type of items used with the achievement measure, utilizing the inquisitory approach as the method of instruction. The questions were identical to those which appeared on the final test in terms of order and format. Only the specific instances were different.

ACHIEVEMENT MEASURE

A single three-part 41 question achievement test, developed by the experimenter, was used as the dependent measure. The online test covered the range of Xenograde objectives, beginning with the more elementary and advancing to the more complex. The test was divided into three subtests corresponding to facts, simple rules, and complex rules. The first part (questions 1 - 11) dealt strictly with factual information covered in the introductory segment. The second third (questions 12 - 25) involved some factual information and the simple rules which dealt with activity in the nucleus, with no more than one satellite exchanging alphons. The final, more difficult, third of the test (questions 26 - 41) focused on the more complex rules involving predictions of satellite position, with both satellites exchanging alphons.

Frustration Rating

As part of the online test, each student was asked to rate their level of frustration with using the Xenograde materials given to them by assigning a number between 1 and 10, with 10 representing the greatest degree of frustration.

PROCEDURE

The study was conducted over three consecutive days in the High School's computer lab. The first day the teachers explained to the classes that they were selected to be involved in an experimental study involving a computer simulation over the next three days. They were told that their performance over the study period would in no way affect their standing in the class, but they were asked to do their best. The experimenter then explained the effort that had gone into the development of the simulation, and that the goals of the study were to explore various approaches to using the simulator, and the effects that those approaches have upon learning. The three days were then outlined to the students. The were told that the first day would be a general introduction to the simulation, the second day would involve the learning assignment, and the third day would be a test on what they had learned. Student questions were answered, and all subjects were assigned to a computer and worked for approximately 30 minutes on the introductory segment of the program. There were no treatment differentiations with this segment.

The second day the subjects from all four class periods were randomly assigned to one of the three treatments. The subjects were told that the basic task was to use what was given to them to learn all that they could about how the Xenograde molecule works. Because the various treatments were dispersed randomly throughout the lab, they were told to concentrate on the materials they were given and ignore what their neighbor was doing. Since the strategies were not apparent through casual observation there was little chance of contamination across treatments with the close proximity. All three treatment groups worked for the 50 minutes of the class period on their respective materials. The experimenter monitored the activity, answering any technical questions dealing with the operation of the program, and making sure that talking between subjects was kept at a minimum.

The third day the subjects were again assigned to a computer for the administration of the achievement test. At the end of the test, subjects were asked to rate their level of frustration with the task on a scale of 1 to 10, 10 being the highest. Upon completion of the test, the class was sincerely thanked for their participation, and after the last class of the day, questions regarding the details of the Xenograde system were answered.

DATA ANALYSIS

Of the original sixty-seven participants, two were absent one of the three days, and one experienced technical difficulty with the simulator on the second day of the study. To maintain a balanced design a subject was randomly dropped from the remaining unaffected treatment, leaving 21 subjects per treatment included in the analysis.

The analysis consisted of simple analysis of variance of treatment means for the overall test score, the three subtest scores for facts, simple rules, complex rules, and the frustration rating. For any significant main effects from the ANOVA procedure a Scheffe' test was performed to identify differences between means.

RESULTS

The treatment means for overall score, subtest scores, and frustration ratings are shown below in Table 1.

TABLE 1
Treatment Means

	TREATMENT		
	Student Assigned (control)	System Assigned Detached	System Assigned Embedded
Sample Size	21	21	21
Overall Score Mean	14.43	13.95	16.10
Subtest Means:			
Facts	7.67	7.14	7.67
Simple Rules	5.00	5.14	5.67
Complex Rules	1.76	1.67	2.76
Mean Frustration Ratings	7.65	8.16	8.30

An analysis of variance indicated that there were no significant differences between treatment means on overall scores or the facts and simple rules subtests. However, there was a significant main effect for the complex rules subtest, $F(2,60)=4.36$, p .05. A Scheffe' test yielded a significant difference between the System Assigned Detached and the System Assigned Embedded treatments for the Complex Rules subtest. There were no significant differences in frustration ratings across treatments.

A test item analysis showed that the final questions of the test (items 26 - 41) were considerably more difficult, with an average of only 13% answering the questions correctly compared to 68% on the first section (see Table 2 below).

TABLE 2
Item analysis: Average Item Difficulty by Sub-Test

	Items	Ave q	Ave p
Facts	1 - 11	.68	.32
Simple Rules	12 - 25	.38	.62
Complex Rules	26 - 41	.13	.87

p = percent of subjects answering item incorrectly.
q = 1 - p.

DISCUSSION

The purpose of this study was to determine whether system assignment of learning strategies is more effective than leaving subjects on their own, and whether or not giving subjects directions regarding the selection of learning strategies is as effective as embedding the strategy in the instruction itself. The results have failed to support the hypothesis that system assignment of learning strategies is more effective than student assignment, since neither of the system assigned strategy groups scored significantly higher than the student assigned group. However, contrary to expectations, it was shown that embedded strategies were superior to detached strategy directions for the more complex rules. A review of the results indicates some fundamental difficulties which may have contributed to the findings.

One of the primary difficulties was that the Xenograde task requires more extensive pre-training. It is clear, based on performance and the unanimous ratings of frustration, that the subjects did not feel adequately prepared in dealing with the task. The system needs to provide a more solid foundation in the basic operation of the simulator. The introductory segment would be much more effective if it incorporated an interactive approach which would guarantee a minimum understanding of the essential fundamentals of Xenograde by requiring mastery of the basic concepts and functions of the simulator. The constraints of the data collection with the current study limited the introductory segment to a cursory 30 minute overview.

In addition to insufficient pre-training, not enough time was allowed for working on the treatments themselves. The fact that the system assigned embedded treatment group out performed the system assigned detached treatment group on the last third of the test suggests either that the embedded approach is more effective for complex rules, or most likely, that the advantage was one of time management. The embedded group's time was distributed evenly across objectives, meaning that they probably spent more time on the more complex objectives than did the detached groups. If more time was allowed for the treatments, there may be different results.

The type of strategies which are likely to be effective with Xenograde may be unique and relatively uncommon with the type of subject utilized in this study. It may be advisable to study more sophisticated learners, or invest time in training the subjects in the use of specific strategies prior to their involvement with Xenograde.

There are a wide range of possible system assigned treatments which vary in the amount of support provided to the learner in the selection and utilization of learning strategies. This study attempted to investigate the impact of what might be considered the two extremes; complete student assignment on one hand, a complete system assignment (embedded) on the other, with a system assigned (detached) treatment which was somewhere in between. A natural extension of the current study would be to investigate the range of possible treatments varying in the amount of support provided to the learner to yield more information regarding the optimal system assignment of strategies.

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APPENDIX A

XENOGRADE OBJECTIVES

XENOGRADE OBJECTIVES

The following list comprises the complete set of objectives of the Xenograde science. At the completion of the instruction the subject will be able to;

1. Identify which PHASE the system is in from the simulator display.

2. Identify the VELOCITY of a given satellite from the simulator display.

3. Identify the CHARGE of a given satellite from the simulator display.

4. Identify when a BLIP occurred from the simulator display.

5. Predict alphon position in the nucleus; without exchange, without phase change, and during inhale phase.

6. Predict alphon position in the nucleus; without exchange, without phase change, and during exhale phase.

7. Predict alphon position in the nucleus; without exchange, with a change in phase from inhale to exhale.

8. Predict alphon position in the nucleus; without exchange, with a change in phase from exhale to inhale.

9. Predict alphon position in the nucleus; with 1 satellite exchanging alphons without phase change, and during inhale phase.

10. Predict alphon position in the nucleus; with 1 satellite exchanging alphons, without phase change, and during exhale phase.

11. Predict alphon position in the nucleus; with 1 satellite exchange alphons, with a change in phase from inhale to exhale.

12. Predict alphon position in the nucleus; with 1 satellite exchanging alphons, with a change in phase from exhale to inhale.

13. Predict alphon position in the nucleus; with 2 satellites exchanging alphons, without phase change, and during inhale phase.

14. Predict alphon position in the nucleus; with 2 satellites exchanging alphons, without phase change, and during exhale phase.

15. Predict alphon position in the nucleus; with 2 satellites exchanging alphons, with a change in phase from inhale to exhale.

16. Predict alphon position in the nucleus; with 2 satellites exchanging alphons, with a change in phase from exhale to inhale.

17. Predict satellite position; without reflection, and with a positive charge.

18. Predict satellite position; without reflection, and with a negative charge.

19. Predict satellite position; with orbit reflection.

20. Predict satellite position; with nucleus reflection, and without exchange.

21. Predict satellite position; with nucleus reflection, with exchange during inhale phase, with 1 satellite.

22. Predict satellite position; with nucleus reflection, with exchange during inhale phase, with 2 satellites.

23. Predict satellite position; with nucleus reflection, with exchange during exhale phase, with 1 satellite.

24. Predict satellite position; with nucleus reflection, with exchange during exhale phase, with 2 satellites.

25. Predict when a blip will occur for a whole numbered blip.

26. Predict when a blip will occur for a fractional numbered blip.

27. Predict the change in satellite charge; with 1 blip, during inhale phase.

28. Predict the change in satellite charge; with 1 blip, during exhale phase.

29. Predict the change in satellite charge; with 2 blips, during inhale phase.

30. Predict the change in satellite charge; with 2 blips, during exhale phase.

31. Predict the change in satellite velocity with a change in K.

APPENDIX B

XENOGRADE INTRODUCTION DISPLAYS

WELCOME

to the world of...

X E N O G R A D E   S Y S T E M S

1

Consider yourself an explorer.

Your mission...

To learn all you can about an

unusual molecule named ...

XENOGRADE!

Press the <SPACE BAR> to continue...

2

Before you begin your adventure, you will need to be briefed on what to expect as you enter this unexplored world of Xenograde Systems!

You will need to let your curiosity be your guide as you try to learn all that you can about what makes a Xenograde System work.

For the next few minutes you will be given the little information that is known about Xenograde Systems.

Press the <SPACE BAR> to continue...

3

You will need to take your time and read each page carefully before you press the SPACE BAR. You will be given the information only once, so be be sure to follow it closely.

After you have had a chance to explore Xenograde Systems, you will be asked to share what you have learned by answering some questions.

Press the <SPACE BAR> to continue...

4

You will have help in your assignment by the latest in modern monitoring equipment.

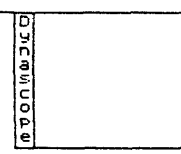
These devices were made to measure the activity of very small particles.

Since Xenograde Systems are too small to be seen without help... these measurements are the only source of information about Xenograde Systems.

Let's learn more about these devices.

Press the <SPACE BAR> to continue...

5



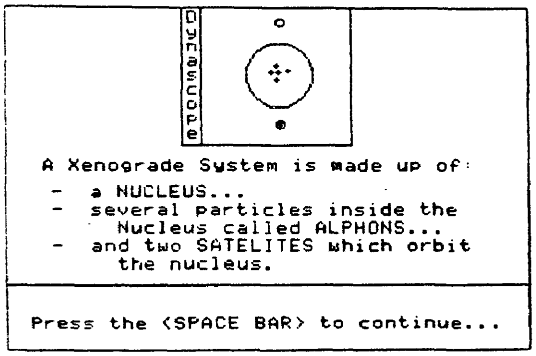
One of the most important devices is called the DYNASCOPE. This monitors the activity of a Xenograde molecule by displaying it's image as it moves.

Let's use the DYNASCOPE to introduce you to an actual Xenograde System...

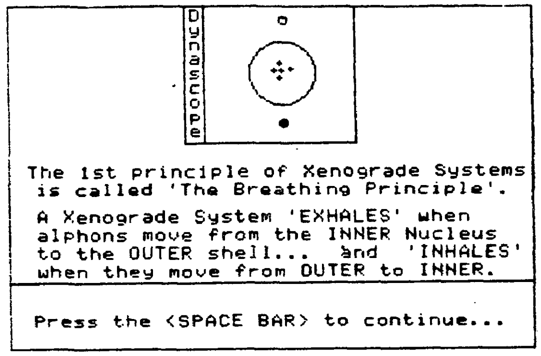
Press the <SPACE BAR> to continue...

6

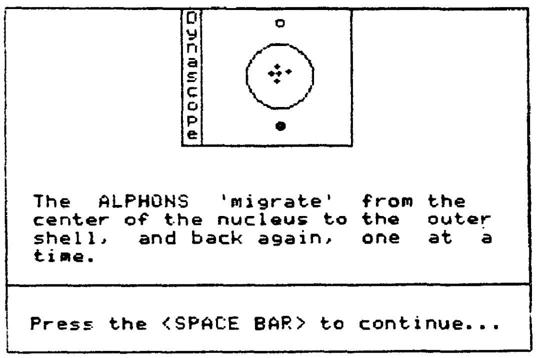
Xenograde Introduction Displays


Dynascope
A Xenograde System is made up of:
- a NUCLEUS...
- several particles inside the Nucleus called ALPHONS...
- and two SATELITES which orbit the nucleus.
Press the <SPACE BAR> to continue...

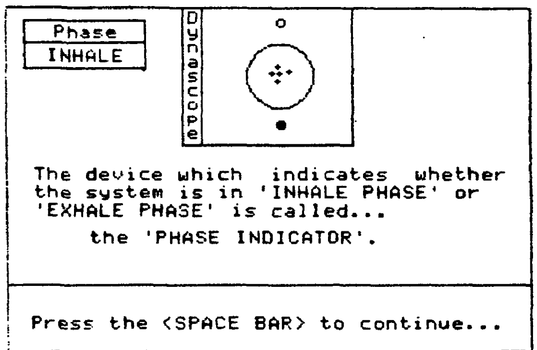
7


Dynascope
The 1st principle of Xenograde Systems is called 'The Breathing Principle'.
A Xenograde System 'EXHALES' when alphons move from the INNER Nucleus to the OUTER shell... and 'INHALES' when they move from OUTER to INNER.
Press the <SPACE BAR> to continue...

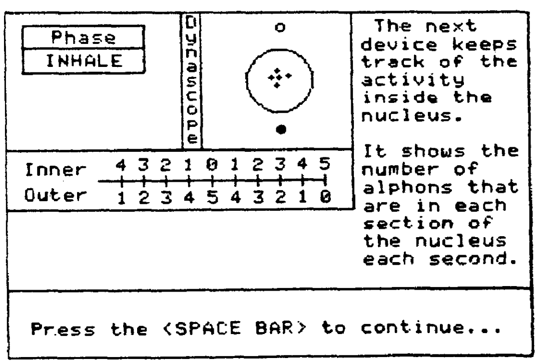
8


Dynascope
The ALPHONS 'migrate' from the center of the nucleus to the outer shell, and back again, one at a time.
Press the <SPACE BAR> to continue...

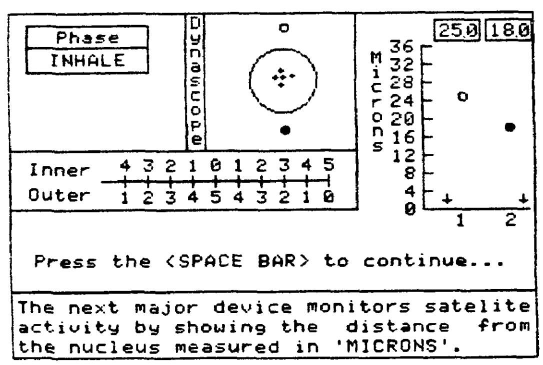
9


Phase
INHALE
Dynascope
The device which indicates whether the system is in 'INHALE PHASE' or 'EXHALE PHASE' is called...
the 'PHASE INDICATOR'.
Press the <SPACE BAR> to continue...

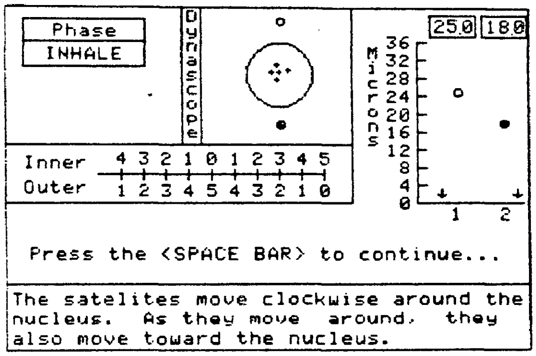
10


Phase
INHALE
Dynascope
Inner 4 3 2 1 0 1 2 3 4 5
Outer 1 2 3 4 5 4 3 2 1 0
The next device keeps track of the activity inside the nucleus.
It shows the number of alphons that are in each section of the nucleus each second.
Press the <SPACE BAR> to continue...

11


Phase
INHALE
Dynascope
Inner 4 3 2 1 0 1 2 3 4 5
Outer 1 2 3 4 5 4 3 2 1 0
25.0 18.0
Microns
36 32 28 24 20 16 12 8 4 0
1 2
Press the <SPACE BAR> to continue...
The next major device monitors satelite activity by showing the distance from the nucleus measured in 'MICRONS'.

12



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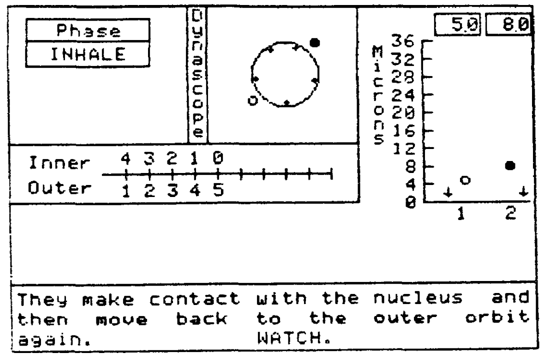

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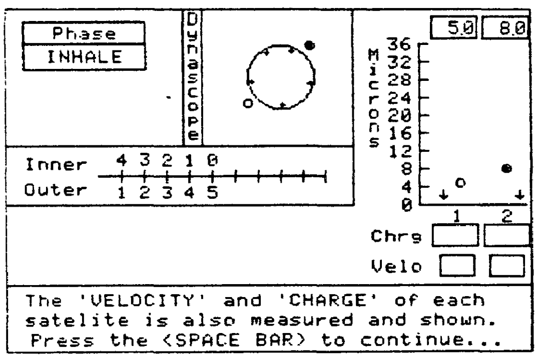

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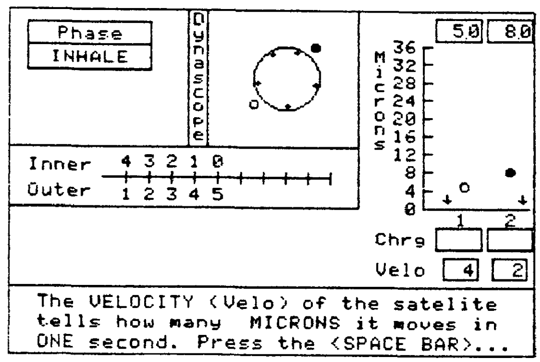

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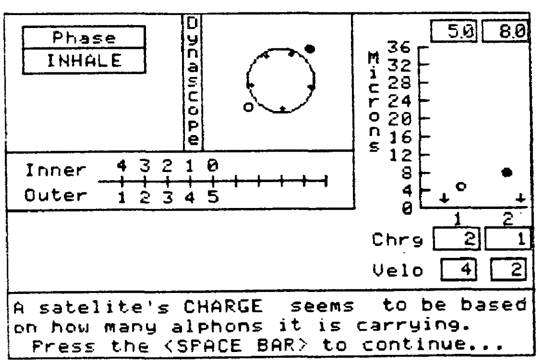

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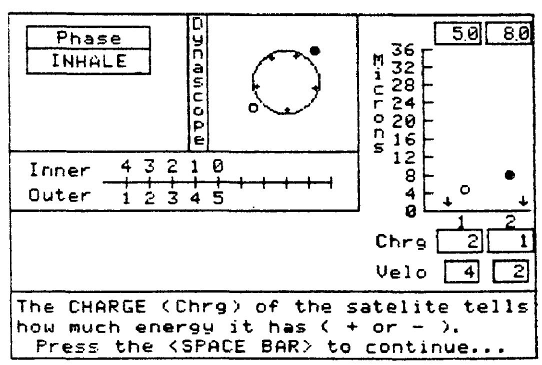

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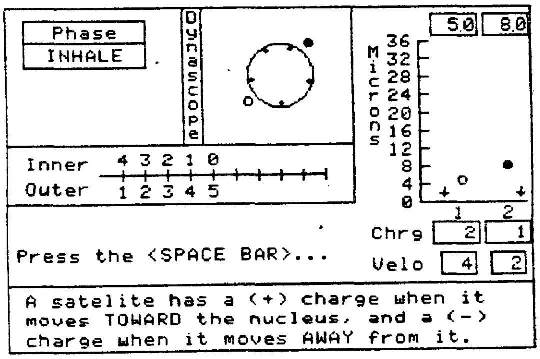

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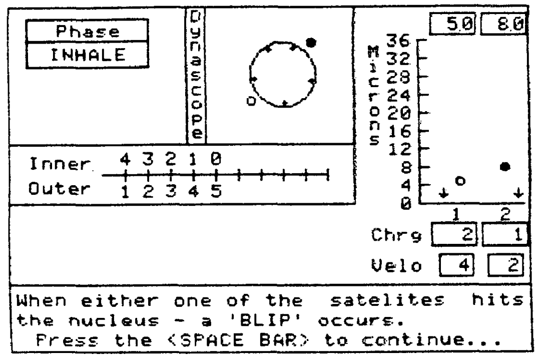

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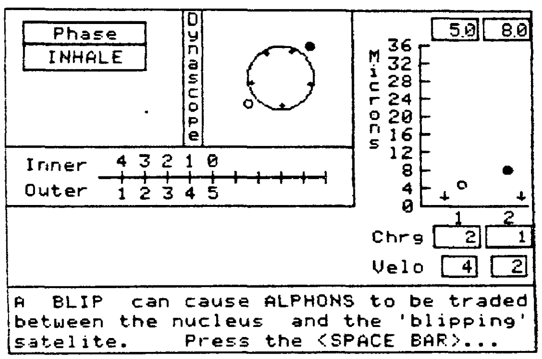

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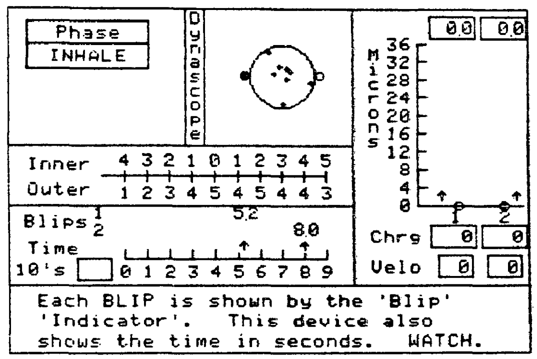

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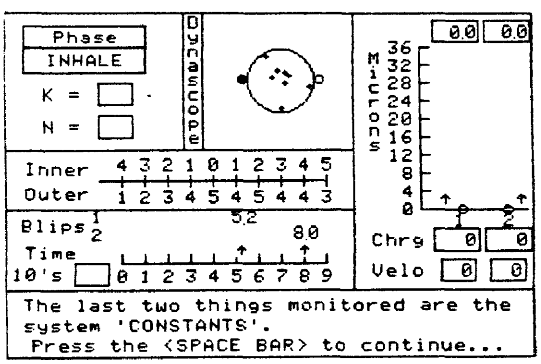

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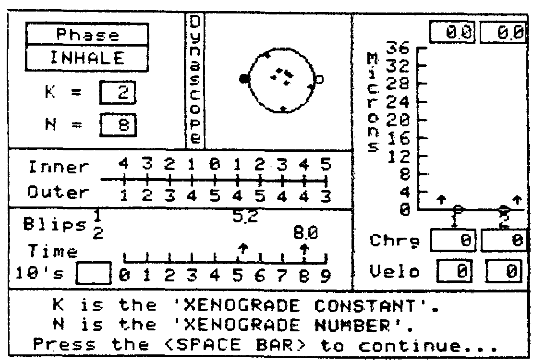

24

APPENDIX C

HANDOUTS

X E N O G R A D E

A

SIMULATION

by

Tom R. Eucker

Torrence High School

October 1983

USING THE XENOGRADE SIMULATION

Your task is to learn as much as you can about how Xenograde Systems work. The simulator was designed to help. In the bottom section of the screen, you should see the following;

XENOGRADE SYSTEMS
Press <RETURN> to stop and start...
Press <SPACE BAR> to change conditions.

While the simulator is working press the key labeled 'RETURN' to stop the action. Press RETURN a second time to start it running again. This will give you a chance to study the display without it moving.

You can also change certain conditions of the simulator by pressing the 'SPACE BAR' while the simulator is working. This will cause the following to be displayed in the bottom of the screen;

	<SPACE> for next.
System Constant - K	<RETURN> to accept.
INHALE Phase	<ESC> to return.

On the list on the left are the conditions that can be modified. Pressing the SPACE BAR will advance the marker (the green bar) to the next choice. The choices will continue to roll past each time you press SPACE. Pressing ESC will cause the simulator to run again without changes. When the marker is over the condition you wish to change press RETURN. You will then be shown the current value and asked to enter the change. The range of allowed values is shown in between the [ ]. Pressing RETURN alone, without entering a value, will make no change. The complete list of conditions that may be changed are;

System Constant - K	Value of K.
INHALE Phase	Set Phase to INHALE.
EXHALE Phase	Set Phase to EXHALE.
Inner Nucleus	# of alphons in the inner section.
Outer Nucleus	# of alphons in the outer section.
Satelite 1 Charge	Charge of satelite 1.
Satelite 2 Charge	Charge of satelite 2.
Distance 1	Distance of satelite 1 from nucleus.
Distance 2	Distance of satelite 2 from nucleus.

By selectively changing the above conditions you can control the exploration of Xenograde Systems.

STRATEGIES FOR EXPLORING XENOGRADE SYSTEMS

The most effective way to approach the problem you have been given is to deal with small parts of the system one at a time. This can be done by controlling various portions of the system while you explore another.

For example; if you could stop the satelites from moving it would be easier to follow what goes on inside the nucleus. This can be done by changing the satelites velocity to 0 when they are away from the nucleus.

In addition to focusing on small parts of the system, it is very helpful to address specific questions to be answered in your exploration. The list below covers the basic knowledge of Xenograde Systems.

By trying to answer each question in turn, you will focus your attention on the most important features of a Xenograde System.

You should PRACTICE answering these questions in the order given, since understanding the first characteristics will help you understand the ones that come later.

Try to practice with different conditions to help you fully understand the different situations that are possible.

QUESTIONS

1. How many alphons will be in the inner or outer section of the nucleus after a set length of time (say 5 seconds) while in INHALE Phase.

2. How many alphons will be in the inner or outer section of the nucleus after a set length of time (say 4 seconds) while in EXHALE Phase.

3. How many alphons will be in the inner or outer section of the nucleus after a set length of time (say 6 seconds) while in starting in INHALE phase and ending in EXHALE Phase.

4. What would happen to the velocity of the satelites when K is changed?

5. What would the charge of a satelite be after making contact with the nucleus while in INHALE phase?

6. What would the charge of a satelite be after making contact with the nucleus while in EXHALE phase?

7. How many alphons would be in the nucleus (in either inner or outer sections) after a satelite makes contact with the nucleus while in INHALE phase?

8. How many alphons would be in the nucleus (in either inner or outer sections) after a satelite makes contact with the nucleus while in EXHALE phase?

9. How many alphons would be in the nucleus (in either inner or outer sections) after TWO satelites make contact with the nucleus while in either EXHALE or INHALE phase?

10. When will the satelites make contact with the nucleus (to the nearest tenth of a second) ?

11. How many microns from the nucleus will the satelites be after a set number of seconds for either INHALE or EXHALE phase?

12. How many microns from the nucleus will the satelites be after a set number of seconds, after making contact with the nucleus, for either INHALE or EXHALE phase?

If you can answer the above questions with all possible conditions, you will have mastered Xenograde Systems.

DIRECTIONS FOR EXPLORING XENOGRADE SYSTEMS

The simulation will guide you through a number of examples, where you will be asked to answer some very basic questions.

You will be told immediately whether your guess was correct or not and be shown the actual action take place.

These practice questions are nearly identical to the kinds of questions you will be asked on the following day which will find out how much you have learned about Xenograde Systems.

APPENDIX D

XENOGRADE TEST PROBLEMS

XENOGRADE TEST PROBLEMS

Online Achievement Measure Data

TEST PROBLEM # 1

EXHALE = False CONSTANT = 2
SECONDS = 0 10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
The particles in the nucleus are called ALPHONS. TRUE or FALSE?

TEST PROBLEM # 2

EXHALE = True CONSTANT = 2
SECONDS = 0 10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
The orbiting particles are called ELECTRONS. TRUE or FALSE?

TEST PROBLEM # 3

EXHALE = True CONSTANT = 2
SECONDS = 0 10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
A BLIP is when the Phase changes. TRUE or FALSE?

TEST PROBLEM # 4

EXHALE = True CONSTANT = 2
SECONDS = 0 10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
Alphons move from outer to inner during INHALE Phase. TRUE or FALSE?

TEST PROBLEM # 5

EXHALE = True   CONSTANT = 2
SECONDS = 0   10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
The System Constant (K) is related to the number of satelites. T or F?

TEST PROBLEM # 6

EXHALE = True   CONSTANT = 2
SECONDS = 0   10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
N is the total number of alphons in the nucleus. TRUE or FALSE?

TEST PROBLEM # 7

EXHALE = True   CONSTANT = 2
SECONDS = 0   10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
Alphons are sometimes traded between the satelites and the nucleus. T or F?

TEST PROBLEM # 8

EXHALE = True   CONSTANT = 2
SECONDS = 0   10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
BLIPS occur when the satelites collide with the nucleus. TRUE or FALSE?

TEST PROBLEM # 9

EXHALE = True   CONSTANT = 2
SECONDS = 0   10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
K is related to the charge and velocity of the satelites. TRUE or FALSE?

TEST PROBLEM # 10

EXHALE = True   CONSTANT = 2
SECONDS = 0   10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
A satelites charge is related to the number of alphons it is carrying. T/F?

TEST PROBLEM # 11

EXHALE = False   CONSTANT = 2
SECONDS = 9   10's = 5

INNER = 1 2 3 4 5 4 3 2 1 0
OUTER = 4 3 2 1 0 1 2 3 4 5

	Satelite 1	Satelite 2
CHARGE =	-1	2
DISTANCE =	8.0	16.0
BLIP =	5.0	

PROMPT LINES
What breathing phase is this system in ?

TEST PROBLEM # 12

EXHALE = True   CONSTANT = 2
SECONDS = 6   10's = 6

INNER = 1 2 3 4 5 6 7
OUTER = 4 3 2 3 2 1 0

	Satelite 1	Satelite 2
CHARGE =	-1	0
DISTANCE =	22.0	0.0
BLIP =		3.0

PROMPT LINES
What is the velocity of satelite 2 ?

TEST PROBLEM # 13

EXHALE = False   CONSTANT = 3
SECONDS = 5   10's = 7

INNER = 3 2 1 0 1 2
OUTER = 3 4 5 6 5 4

	Satelite 1	Satelite 2
CHARGE =	1	-1
DISTANCE =	32.0	16.0
BLIP =		

PROMPT LINE
What is the charge of satelite 1 ?

TEST PROBLEM # 14

EXHALE = False   CONSTANT = 3
SECONDS = 7   10's = 8

INNER = 5 4 3 2 1 0 1 2
OUTER = 1 2 3 4 5 6 6 5

	Satelite 1	Satelite 2
CHARGE =	0	1
DISTANCE =	0.0	20.0
BLIP =	5.7	

PROMPT LINES
When did satelite 1 hit the nucleus?
(to the nearest tenth of a second)

TEST PROBLEM # 15

EXHALE = False   CONSTANT = 2
SECONDS = 2   10's = 2

INNER = 3 4 5
OUTER = 6 5 4

	Satelite 1	Satelite 2
CHARGE =	-2	-1
DISTANCE =	25.2	15.0
BLIP =		

PROMPT LINES
How many alphons will be in the inner section of the nucleus after 3 seconds?

TEST PROBLEM # 16

EXHALE = True   CONSTANT = 2
SECONDS = 3   10's = 3

INNER = 8 9 8 7
OUTER = 1 0 1 2

	Satelite 1	Satelite 2
CHARGE =	-1	1
DISTANCE =	28.0	24.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 4 seconds?

TEST PROBLEM # 17

EXHALE = False CONSTANT = 2
SECONDS = 5 10's = 2

INNER = 3 4 5 6 7 8
OUTER = 6 5 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISANCE =	34.7	21.0
BLIP =		

PROMPT LINES
What will N be after 6 more seconds?

TEST PROBLEM # 18

EXHALE = True CONSTANT = 1
SECONDS = 7 10's = 3

INNER = 8 9 8 7 6 5 4 3
OUTER = 1 0 1 2 3 4 5 6

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	36.0	16.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 5 seconds?

TEST PROBLEM # 19

EXHALE = False CONSTANT = 2
SECONDS = 4 10's = 1

INNER = 1 0 1 2 3
OUTER = 2 3 6 5 4

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	33.0	10.0
BLIP =	2.0	

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 8 more seconds?

TEST PROBLEM # 20

EXHALE = False CONSTANT = 2
SECONDS = 4 10's = 1

INNER = 1 0 1 2 3
OUTER = 2 3 6 5 4

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	33.0	10.0
BLIP =	2.0	

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 8 more seconds?

TEST PROBLEM # 21

EXHALE = True CONSTANT = 3
SECONDS = 5 10's = 7

INNER = 5 6 7 8 9 8
OUTER = 4 3 2 1 0 1

	Satelite 1	Satelite 2
CHARGE =	1	-2
DISTANCE =	13.0	18.0
BLIP =		

PROMPT LINES
What will the velocity of satelite 2 be if K is changed from 3 to 1 ?

TEST PROBLEM # 22

EXHALE = False CONSTANT = 1
SECONDS = 0 10's = 7

INNER = 3
OUTER = 5

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	6.0	13.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 5 seconds?

TEST PROBLEM # 23

EXHALE = True CONSTANT = 2
SECONDS = 1 10's = 3

INNER = 5 4
OUTER = 4 5

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	10.7	33.0
BLIP =		

PROMPT LINES
What will N be after 3 more seconds ?

TEST PROBLEM # 24

EXHALE = False CONSTANT = 2
SECONDS = 1 10's = 4

INNER = 3 4
OUTER = 3 2

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	28.0	2.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 4 seconds?

TEST PROBLEM # 25

EXHALE = True CONSTANT = 1
SECONDS = 2 10's = 8

INNER = 3 2 1
OUTER = 4 5 6

	Satelite 1	Satelite 2
CHARGE =	-1	3
DISTANCE =	9.0	9.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 6 seconds?

TEST PROBLEM # 26

EXHALE = False CONSTANT = 1
SECONDS = 1 10's = 8

INNER = 2 3
OUTER = 5 4

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	1.0	2.0
BLIP =		

PROMP LINES
How many alphons will be in the inner section of the nucleus after 4 seconds?

TEST PROBLEM # 27

EXHALE = True CONSTANT = 1
SECONDS = 4 10's = 7

INNER = 5 6 7 8 7
OUTER = 3 2 1 0 1

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	1.0	5.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 4 seconds?

TEST PROBLEM # 28

EXHALE = False CONSTANT = 2
SECONDS = 5 10's = 5

INNER = 1 0 1 2 3 4
OUTER = 4 5 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	4.0	2.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 5 seconds?

TEST PROBLEM # 29

EXHALE = True CONSTANT = 1
SECONDS = 4 10's = 10

INNER = 5 6 7 8 9
OUTER = 4 3 2 1 0

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	2.0	22.0
BLIP =		

PROMPT LINES
What will N be after 12 more seconds ?

TEST PROBLEM # 30

EXHALE = False CONSTANT = 1
SECONDS = 2 10's = 24

INNER = 1 0 1
OUTER = 6 7 6

	Satelite 1	Satelite 2
CHARGE =	-1	3
DISTANCE =	8.0	9.0
BLIP =		

PROMPT LINES
What will the charge of satelite 2 be after 4 more seconds ?

TEST PROBLEM # 31

EXHALE = True CONSTANT = 1
SECONDS = 1 10's = 25

INNER = 9 8
OUTER = 0 1

	Satelite 1	Satelite 2
CHARGE =	1	-1
DISTANCE =	2.0	6.0
BLIP =		

PROMPT LINES
What will the charge of satelite 1 be after 4 more seconds ?

TEST PROBLEM # 32

EXHALE = False CONSTANT = 2
SECONDS = 0 10's = 5

INNER = 1
OUTER = 6

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	4.0	16.0
BLIP =		

PROMPT LINES
What will the charge of satelite 2 be after 6 more seconds ?

TEST PROBLEM # 33

EXHALE = True CONSTANT = 2
SECONDS = 1 10's = 6

INNER = 7 6
OUTER = 0 1

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	8.0	4.0
BLIP =		

PROMPT LINES
What will the charge of satelite 1 be after 5 more seconds ?

TEST PROBLEM # 34

EXHALE = True CONSTANT = 1
SECONDS = 6 10's = 7

INNER = 0 1 2 3 4 5 6
OUTER = 6 5 4 3 2 1 0

	Satelite 1	Satelite 2
CHARGE =	2	2
DISTANCE =	3.0	4.0
BLIP =		

PROMPT LINES
When will satelite 1 hit the nucleus ? (to the nearest tenth of a second)

TEST PROBLEM # 35

```
EXHALE = True           CONSTANT =  1
SECONDS = 6                  10's =  8

INNER = 0 1 2 3 4 5 6
OUTER = 6 5 4 3 2 1 0

           Satelite 1   Satelite 2
CHARGE =       2             2
DISTANCE =    3.0           4.0
BLIP =

PROMPT LINES
 When will satelite 2 hit the nucleus ?
  (to the nearest tenth of a second)
```

TEST PROBLEM # 36

```
EXHALE = False          CONSTANT =  1
SECONDS = 7                  10's =  7

INNER = 5 4 3 2 1 0 1 2
OUTER = 2 3 4 5 6 7 6 5

           Satelite 1   Satelite 2
CHARGE =       2            -1
DISTANCE =    5.0          32.0
BLIP =

PROMPT LINES
How many microns from the nucleus will
 satelite 2 be after 6 more seconds ?
```

TEST PROBLEM # 37

```
EXHALE = False          CONSTANT =  1
SECONDS = 8                  10's =  8

INNER = 7 6 5 4 3 2 1 0 1
OUTER = 2 3 4 5 6 7 8 9 8

           Satelite 1   Satelite 2
CHARGE =       1            -1
DISTANCE =    3.0          27.0
BLIP =

PROMPT LINES
 How many microns from the nucleus will
  satelite 1 be after 5 more seconds ?
```

TEST PROBLEM # 38

```
EXHALE = False          CONSTANT =  1
SECONDS = 6                  10's =  6

INNER = 4 3 2 1 0 1 2
OUTER = 4 5 6 7 8 7 6

           Satelite 1   Satelite 2
CHARGE =      -1             2
DISTANCE =    15.0          4.0
BLIP =

PROMPT LINES
How many microns from the nucleus will
 satelite 2 be after 7 more seconds ?
```

TEST PROBLEM # 39

```
EXHALE = False          CONSTANT =  1
SECONDS = 2                  10's =  7

INNER = 0 1 2
OUTER = 7 6 5

           Satelite 1   Sate,ite 2
CHARGE =       1             3
DISTANCE =    2.0           9.0
BLIP =

PROMPT LINES
 How many microns from the nucleus will
  satelite 2 be after 8 more seconds ?
```

TEST PROBLEM # 40

```
EXHALE = True           CONSTANT =  1
SECONDS = 0                  10's =  5

INNER = 8
OUTER = 0

           Satelite 1   Satelite 2
CHARGE =       0            -2
DISTANCE =    0.0          10.0
BLIP =

PROMPT LINES
How many microns from the nucleus will
 satelite 1 be after 5 more seconds ?
```

TEST PROBLEM # 41

EXHALE = True CONSTANT = 1
SECONDS = 0 10's = 6

INNER = 8
OUTER = 1

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	3.0	1.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 6 more seconds ?

TEST PROBLEM # 42

EXHALE = True CONSTANT = 2
SECONDS = 0 10's = 0

INNER = 0
OUTER = 0

	Satelite 1	Satelite 2
CHARGE =	0	0
DISTANCE =	0.0	0.0
BLIP =		

PROMPT LINES
On a scale of 1 to 10, rate how frustrated you were during the study.

APPENDIX E

XENOGRADE PRACTICE PROBLEMS

XENOGRADE PRACTICE PROBLEMS

System Assigned Embedded Data

PRACTICE PROBLEM # 1

EXHALE = True   CONSTANT = 2
SECONDS = 4   10's = 3

INNER = 5 6 5 4 3
OUTER = 1 0 1 2 3

	Satelite 1	Satelite 2
CHARGE =	-1	1
DISTANCE =	30.0	22.0
BLIP =		

PROMPT LINES
What phase of breathing is this system in (INHALE or EXHALE) ?

POSITIVE FEEDBACK LINES
That is RIGHT. The system is currently EXHALEing.

NEGATIVE FEEDBACK LINES
NO I'm sorry, the system is currently EXHALEing.

Answer = EXHALE

REMEDIAL PROBLEM # 1

EXHALE = False   CONSTANT = 2
SECONDS = 8   10's = 3

INNER = 5 6 5 4 3 2 1 0 1
OUTER = 1 0 1 2 3 4 5 6 5

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	34.0	14.0
BLIP =		

PROMPT LINES
Is this system in INHALE or EXHALE phase ?

POSITIVE FEEDBACK LINES
That's the idea! This system is in INHALE phase.

NEGATIVE FEEDBACK LINES
Not quite. Try looking at the 'Phase' box, and notice how the alphons move.

Answer = INHALE

PRACTICE PROBLEM # 2

EXHALE = False CONSTANT = 2
SECONDS = 2 10's = 4

INNER = 3 4 5
OUTER = 3 2 1

	Satelite 1	Satelite 2
CHARGE =	2	1
DISTANCE =	26.0	6.0
BLIP =		

PROMPT LINES
What is the VELOCITY (Velo) of satelite 2 ?

POSITIVE FEEDBACK LINES
Very good! Satelite 2 is moving 2 microns every second.

NEGATIVE FEEDBACK LINES
No, that's not right. Try again, and notice the 'Velo' box.

Answer = 2

REMEDIAL PROBLEM # 2

EXHALE = True CONSTANT = 3
SECONDS = 4 10's = 4

INNER = 3 4 5 6 5
OUTER = 3 2 1 0 1

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	22.0	2.0
BLIP =		

PROMPT LINES
What is the VELOCITY (Velo) of satelite 1 ?

POSITIVE FEEDBACK LINES
Excellent! Now you've got it. Satelite1 is moving at 3 microns/sec.

NEGATIVE FEEDBACK LINES
Sorry, wrong again. The answer is found in the first box marked 'Velo'.

Answer = 3

PRACTICE PROBLEM # 3

EXHALE = True CONSTANT = 2
SECONDS = 2 10's = 2

INNER = 5 4 3
OUTER = 1 2 3

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	6.0	26.0
BLIP =		

PROMPT LINES
What is the CHARGE (Chrg) of satelite 2 ?

POSITIVE FEEDBACK LINES
Good! Satelite 2 has a charge of -1.

NEGATIVE FEEDBACK LINES
No. Satelite 2 has a charge of -1.

Answer = -1

REMEDIAL PROBLEM # 3

EXHALE = True CONSTANT = 2
SECONDS = 2 10's = 2

INNER = 5 4 3
OUTER = 1 2 3

	Satelite 1	Satelite 2
CHARGE =	3	-1
DISTANCE =	6.0	26.0
BLIP =		

PROMPT LINES
What is the CHARGE (Chrg) of satelite 1 ?

POSITIVE FEEDBACK LINES
Alright! The charge of satelite 1 is 3.

NEGATIVE FEEDBACK LINES
Hmm, that's wrong. Look at the box labeled 'Chrg'.

Answer = 3

PRACTICE PROBLEM # 4

EXHALE = True CONSTANT = 2
SECONDS = 4 10's = 2

INNER = 5 4 3 2 1
OUTER = 1 2 3 0 1

	Satelite 1	Satelite 2
CHARGE =	-6	-1
DISTANCE =	12.0	30.0
BLIP =	3.0	

PROMPT LINES
When did satelite 1 hit the nucleus?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
Very observant! The satelite made contact (blipped) at 23.0 seconds.

NEGATIVE FEEDBACK LINES
No. It hit at 23.0 seconds. Be sure to include the 10's.

Answer = 23.0

PRACTICE PROBLEM # 5

EXHALE = False CONSTANT = 3
SECONDS = 7 10's = 9

INNER = 7 6 5 4 3 2 1 0
OUTER = 2 3 4 0 1 2 1 0

	Satelite 1	Satelite 2
CHARGE =	-3	6
DISTANCE =	3.0	18.0
BLIP =	5.7	3.0

PROMPT LINES
When did satelite 1 make contact with the nucleus (blip) ?

POSITIVE FEEDBACK LINES
Very fine! At 95.7 seconds, satelite 1 made contact with the nucleus.

NEGATIVE FEEDBACK LINES
No that's wrong. It was 95.7 seconds; 90 (10's) + 5.7 (blip) = 95.7.

Answer = 95.7

REMEDIAL PROBLEM # 4

EXHALE = True CONSTANT = 2
SECONDS = 6 10's = 3

INNER = 1 0 1 2 3 2 1
OUTER = 2 3 2 1 0 0 1

	Satelite 1	Satelite 2
CHARGE =	-6	1
DISTANCE =	12.0	18.0
BLIP =	5.0	

PROMPT LINES
When did satelite 1 hit the nucleus?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
That's better! Satelite 1 made contact (blipped) at 35.0 seconds.

NEGATIVE FEEDBACK LINES
I'm afraid not. The answer is 35.0. Remember the decimal place.

Answer = 35.0

REMEDIAL PROBLEM # 5

EXHALE = False CONSTANT = 2
SECONDS = 4 10's = 4

INNER = 3 2 1 0 1
OUTER = 0 1 0 1 0

	Satelite 1	Satelite 2
CHARGE =	-1	-3
DISTANCE =	28.0	12.0
BLIP =		2.0

PROMPT LINES
When did satelite 2 hit the nucleus?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
Absolutely right! Satelite 2 made contact (blipped) at 42.0 seconds.

NEGATIVE FEEDBACK LINES
Bad news. That is not the right answer it hit the nucleus at 42.0 seconds.

Answer = 42.0

PRACTICE PROBLEM # 6

EXHALE = False CONSTANT = 1
SECONDS = 5 10's = 1

INNER = 4 3 2 1 0 1
OUTER = 2 3 4 5 6 5

	Satelite 1	Satelite 2
CHARGE =	-1	-1
DISTANCE =	33.0	15.0
BLIP =		

PROMPT LINES
How many alphons will be in the inner section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Very good! 3 more alphons 'migrated' from the outer section while inhaling.

NEGATIVE FEEDBACK LINES
Good try. The correct answer is 4. 3 more moved from the outer section.

Answer = 4

REMEDIAL PROBLEM # 6

EXHALE = False CONSTANT = 1
SECONDS = 1 10's = 5

INNER = 0 1
OUTER = 6 5

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	29.0	21.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Good job! After 3 move to the inner section, 2 will remain.

NEGATIVE FEEDBACK LINES
No. Watch the Phase. Alphons move in during inhale and out during exhale.

Answer = 2

PRACTICE PROBLEM # 7

EXHALE = True CONSTANT = 1
SECONDS = 2 10's = 3

INNER = 4 5 6
OUTER = 2 1 0

	Satelite 1	Satelite 2
CHARGE =	1	-1
DISTANCE =	22.0	32.0
BLIP =		

PROMPT LINES
How many alphons will be in the inner section of the nucleus after 5 seconds?

POSITIVE FEEDBACK LINES
Yes! 5 more will migrate, making a total of only 1 in the inner section.

NEGATIVE FEEDBACK LINES
No. 5 more will migrate out during exhale phase leaving only 1 alphon.

Answer = 1

REMEDIAL PROBLEM # 7

EXHALE = True CONSTANT = 1
SECONDS = 2 10's = 2

INNER = 6 5 4
OUTER = 0 1 2

	Satelite 1	Satelite 2
CHARGE =	I	-1
DISTANCE =	32.0	22.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 2 seconds?

POSITIVE FEEDBACK LINES
Now you've got the idea! In 2 seconds 2 more will 'migrate' making 4 total.

NEGATIVE FEEDBACK LINES
No, I'm sorry. In 2 seconds, 2 more will 'migrate', making a total of 4.

Answer = 4

PRACTICE PROBLEM # 8

EXHALE = False   CONSTANT = 2
SECONDS = 1   10's = 5

INNER = 1 2
OUTER = 4 3

	Satelite 1	Satelite 2
CHARGE =	1	-2
DISTANCE =	18.0	24.0
BLIP =		

PROMPT LINES
What will N be after
4 more seconds ?

POSITIVE FEEDBACK LINES
That was pretty easy wasn't it!
N will remain the same at 5.

NEGATIVE FEEDBACK LINES
No. You're probably trying to make it too hard. It stayed at 5.

Answer = 5

REMEDIAL PROBLEM # 8

EXHALE = True   CONSTANT = 2
SECONDS = 3   10's = 8

INNER = 4 5 6 5
OUTER = 2 1 0 1

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	32.0	26.0
BLIP =		

PROMPT LINES
What will N be after
5 more seconds ?

POSITIVE FEEDBACK LINES
That's right! In this situation,
N does not change in 5 seconds.

NEGATIVE FEEDBACK LINES
No, I'm sorry. Unless alphons are traded with satelites, N doesn't change

Answer = 6

PRACTICE PROBLEM # 9

EXHALE = False   CONSTANT = 1
SECONDS = 3   10's = 9

INNER = 2 3 4 5
OUTER = 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	2	1
DISTANCE =	30.0	26.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 4 seconds?

POSITIVE FEEDBACK LINES
Correct! After changing phase from INHALE to EXHALE there will be 3.

NEGATIVE FEEDBACK LINES
No. After changing from INHALE to EXHALE phase, there will be 3.

Answer = 3

REMEDIAL PROBLEM # 9

EXHALE = False   CONSTANT = 1
SECONDS = 6   10's = 11

INNER = 2 1 0 1 2 3 4
OUTER = 3 4 5 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	-3	1
DISTANCE =	24.0	27.0
BLIP =		

PROMPT LINES
How many alphons will be in the inner section of the nucleus after 5 seconds?

POSITIVE FEEDBACK LINES
That's better! After 5 seconds there will be 1 alphon in the inner section.

NEGATIVE FEEDBACK LINES
Not quite. Watch the change in phase from INHALE to EXHALE.

Answer = 1

PRACTICE PROBLEM # 10

EXHALE = True CONSTANT = 3
SECONDS = 1 10's = 12

INNER = 2 1
OUTER = 3 4

	Satelite 1	Satelite 2
CHARGE =	2	1
DISTANCE =	33.0	22.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 5 seconds?

POSITIVE FEEDBACK LINES
Very good! There will only be 1 alphon left in the outer section after 5 secs.

NEGATIVE FEEDBACK LINES
No. There will only be 1 alphon left in the outer section after 5 seconds.

Answer = 1

REMEDIAL PROBLEM # 10

EXHALE = True CONSTANT = 2
SECONDS = 6 10's = 13

INNER = 5 6 7 8 7 6 5
OUTER = 3 2 1 0 1 2 3

	Satelite 1	Satelite 2
CHARGE =	2	1
DISTANCE =	36.0	32.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 7 seconds?

POSITIVE FEEDBACK LINES
That's right! After 7 seconds there will be 6 alphons in the outer section.

NEGATIVE FEEDBACK LINES
No, but hang in there! After 7 seconds there will be 6 alphons there.

Answer = 6

PRACTICE PROBLEM # 11

EXHALE = False CONSTANT = 2
SECONDS = 1 10's = 14

INNER = 1 2
OUTER = 5 4

	Satelite 1	Satelite 2
CHARGE =	-1	1
DISTANCE =	16.0	4.0
BLIP =		

PROMPT LINES
What will the velocity of satelite 2 be when K is changed from 2 to 3 ?

POSITIVE FEEDBACK LINES
Right! The velocity will change from 2 to 3.

NEGATIVE FEEDBACK LINES
Wrong. The velocity will change from 2 to 3.

Answer = 3

REMEDIAL PROBLEM # 11

EXHALE = True CONSTANT = 1
SECONDS = 2 10's = 15

INNER = 3 2 1
OUTER = 3 4 5

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	34.0	10.0
BLIP =		

PROMPT LINES
What will the velocity of satelite 1 be if K is changed from 1 to 3 ?

POSITIVE FEEDBACK LINES
That's it! The velocity will change from 2 to 6.

NEGATIVE FEEDBACK LINES
No. The velocity will change from 2 to 6.

Answer = 6

PRACTICE PROBLEM # 12

EXHALE = False CONSTANT = 2
SECONDS = 6 10's = 15

INNER = 3 2 1 0 1 2 3
OUTER = 3 4 5 6 5 4 3

	Satelite 1	Satelite 2
CHARGE =	-3	1
DISTANCE =	24.0	15.0
BLIP =		

PROMPT LINES
What will the velocity of satelite 1 be if K is changed from 2 to 3 ?

POSITIVE FEEDBACK LINES
Very good! The velocity would change from 6 to 9.

NEGATIVE FEEDBACK LINES
Wrong. The velocity will change from 6 to 9.

Answer = 9

REMEDIAL PROBLEM # 12

EXHALE = True CONSTANT = 2
SECONDS = 1 10's = 16

INNER = 5 4
OUTER = 1 2

	Satelite 1	Satelite 2
CHARGE =	2	-4
DISTANCE =	24.0	35.0
BLIP =		

PROMPT LINES
What will the velocity of satelite 2 be if K is changed from 2 to 1 ?

POSITIVE FEEDBACK LINES
That's more like it! The velocity will change from 8 to 4.

NEGATIVE FEEDBACK LINES
Still not right. The velocity will change from 8 to 4.

Answer = 4

PRACTICE PROBLEM # 13

EXHALE = False CONSTANT = 2
SECONDS = 3 10's = 14

INNER = 1 0 1 2
OUTER = 7 8 7 6

	Satelite 1	Satelite 2
CHARGE =	2	1
DISTANCE =	28.0	18.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 7 more seconds ?

POSITIVE FEEDBACK LINES
That's it! At 2 microns / second it will travel 14 microns in 7 seconds.

NEGATIVE FEEDBACK LINES
No. At 2 microns / second it will travel 14 microns in 7 seconds.

Answer = 4.0

REMEDIAL PROBLEM # 13

EXHALE = False CONSTANT = 2
SECONDS = 0 10's = 16

INNER = 3
OUTER = 3

	Satelite 1	Satelite 2
CHARGE =	2	3
DISTANCE =	32.0	24.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 6 more seconds ?

POSITIVE FEEDBACK LINES
You've got it! At 4 microns / second it will be 8.0 microns away in 6 sec.s

NEGATIVE FEEDBACK LINES
Well, good try. At 4 microns / second it will be 8.0 microns away in 6 sec.s

Answer = 8.0

PRACTICE PROBLEM # 14

EXHALE = True CONSTANT = 2
SECONDS = 6 10's = 16

INNER = 3 4 5 6 5 4 3
OUTER = 3 2 1 0 0 1 2

	Satelite 1	Satelite 2
CHARGE =	2	-2
DISTANCE =	18.0	8.0
BLIP =		4.0

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 3 more seconds ?

POSITIVE FEEDBACK LINES
Excellent! At 4 microns / second it will move another 12 microns in 3 sec.s

NEGATIVE FEEDBACK LINES
No. Moving at 4 microns / second it will move another 12 microns in 3 sec.s

Answer = 20.0

REMEDIAL PROBLEM # 14

EXHALE = False CONSTANT = 1
SECONDS = 1 10's = 17

INNER = 1 2
OUTER = 6 5

	Satelite 1	Satelite 2
CHARGE =	-1	2
DISTANCE =	16.0	22.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 12 more seconds ?

POSITIVE FEEDBACK LINES
That's right! At 1 micron / second it will move another 12 microns in 12 secs

NEGATIVE FEEDBACK LINES
No. At 1 micro. / second it will move another 12 microns away in 12 seconds.

Answer = 28.0

PRACTICE PROBLEM # 15

EXHALE = True CONSTANT = 2
SECONDS = 0 10's = 18

INNER = 3
OUTER = 6

	Satelite 1	Satelite 2
CHARGE =	-1	2
DISTANCE =	32.0	10.8
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 3 more seconds ?

POSITIVE FEEDBACK LINES
Very good! Satelite 1 will be 34.0 microns from the nucleus.

NEGATIVE FEEDBACK LINES
Sorry, no. Satelite 1 will be 34.0 microns away after 3 more seconds.

Answer = 34.0

REMEDIAL PROBLEM # 15

EXHALE = Tru% CONSTANT = 2
SECONDS = 3 10's = 4

INNER = 3 4 5 6
OUTER = 3 2 1 0

	Satelite 1	Satelite 2
CHARGE =	-2	1
DISTANCE =	28.0	4.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 3 more seconds ?

POSITIVE FEEDBACK LINES
That's it! Satelite 1 will change direction at 36.0 microns and return.

NEGATIVE FEEDBACK LINES
No. That's still not correct. It will be at 32.0 microns after 3 secs.

Answer = 32.0

PRACTICE PROBLEM # 16

EXHALE = True CONSTANT = 1
SECONDS = 3 10's = 4

INNER = 3 4 5 6
OUTER = 3 2 1 0

	Satelite 1	Satelite 2
CHARGE =	1	-4
DISTANCE =	28.0	33.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 4 more seconds ?

POSITIVE FEEDBACK LINES
Very good! Satelite 2 will change direction and return to 23.0 microns.

NEGATIVE FEEDBACK LINES
Not quite. It will change direction and return to 23.0 microns away.

Answer = 23.0

REMEDIAL PROBLEM # 16

EXHALE = True CONSTANT = 2
SECONDS = 2 10's = 5

INNER = 5 4 3
OUTER = 3 4 5

	Satelite 1	Satelite 2
CHARGE =	1	-2
DISTANCE =	25.0	31.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 3 more seconds ?

POSITIVE FEEDBACK LINES
That's better! It will change direction and return to 29.0 microns.

NEGATIVE FEEDBACK LINES
Still wrong. It will move to 35.0 then bounce back to 33.0 then to 29.0.

Answer = 29.0

PRACTICE PROBLEM # 17

EXHALE = False CONSTANT = 2
SECONDS = 3 10's = 2

INNER = 1 0 1 2
OUTER = 3 4 3 2

	Satelite 1	Satelite 2
CHARGE =	1	-1
DISTANCE =	2.0	21.5
BLIP =		

PROMPT LINES
What will be the charge of satelite 1 after 3 more seconds ?

POSITIVE FEEDBACK LINES
Good show! The charge of satelite 1 will drop to 0.

NEGATIVE FEEDBACK LINES
No. The charge of satelite 1 will drop to 0.

Answer = 0

REMEDIAL PROBLEM # 17

EXHALE = False CONSTANT = 2
SECONDS = 2 10's = 3

INNER = 1 0 1
OUTER = 3 4 3

	Satelite 1	Satelite 2
CHARGE =	-1	2
DISTANCE =	10.0	8.0
BLIP =		

PROMPT LINES
What will be the charge of satelite 2 after 4 more seconds ?

POSITIVE FEEDBACK LINES
Yes! The charge will drop to 0 again. Notice the change in N.

NEGATIVE FEEDBACK LINES
Wrong. The charge will drop to 0 again. Notice the change in N.

Answer = 0

PRACTICE PROBLEM # 18

```
EXHALE = True          CONSTANT =  2
SECONDS = 7                 10's =  3

INNER = 1 0 1 2 3 4 5 6
OUTER = 3 4 3 2 3 2 1 0

             Satelite 1   Satelite 2
CHARGE =        -1            0
DISTANCE =     22.0          0.0
BLIP =                       4.0
```

PROMPT LINES
What will be the charge of satelite 2 after 3 more seconds ?

POSITIVE FEEDBACK LINES
Correct! The charge will change to -1. Notice the Phase.

NEGATIVE FEEDBACK LINES
I'm sorry. The charge will change to -1. Notice the Phase.

Answer = -1

REMEDIAL PROBLEM # 18

```
EXHALE = True          CONSTANT =  2
SECONDS = 0                 10's =  5

INNER = 3
OUTER = 2

             Satelite 1   Satelite 2
CHARGE =         1           -1
DISTANCE =      2.0          24.0
BLIP =
```

PROMPT LINES
What will be the charge of satelite 1 after 2 more seconds ?

POSITIVE FEEDBACK LINES
That's right! It picked up 4 and changed direction to equal -5.

NEGATIVE FEEDBACK LINES
Nope. It picked up 4 and changed direction to equal a charge of -5.

Answer = -5

PRACTICE PROBLEM # 19

```
EXHALE = False         CONSTANT =  1
SECONDS = 5                 10's =  6

INNER = 3 2 1 0 1 2
OUTR = 4 5 6 7 6 5

             Satelite 1   Satelite 2
CHARGE =         3            1
DISTANCE =      9.0          29.0
BLIP =
```

PROMPT LINES
What will be the charge of satelite 1 after 4 more seconds ?

POSITIVE FEEDBACK LINES
Very good! The charge will drop by 2 and change direction to equal -1.

NEGATIVE FEEDBACK LINES
No, sorry. The charge will drop by 2 and change direction to equal -1.

Answer = -1

REMEDIAL PROBLEM # 19

```
EXHALE = False         CONSTANT =  1
SECONDS = 0                 10's =  7

INNER = 6
OUTER = 2

             Satelite 1   Satelite 2
CHARGE =        -1            2
DISTANCE =      2.0          2.0
BLIP =
```

PROMPT LINES
What will be the charge of satelite 2 after 2 more seconds ?

POSITIVE FEEDBACK LINES
That's it! Satelite 2 will drop 1 and change direction to equal -1.

NEGATIVE FEEDBACK LINES
Wrong again. The answer is -1. Notice the Phase and the value of N.

Answer = -1

PRACTICE PROBLEM # 20

```
EXHALE = True          CONSTANT =  1
SECONDS = 4                10's =  7

INNER = 3 4 5 6 5
OUTER = 3 2 1 0 1

           Satelite 1   Satelite 2
CHARGE =      -1            1
DISTANCE =   34.0          1.0
BLIP =
```

PROMPT LINES
What will be the charge of satelite 2 after 3 more seconds ?

POSITIVE FEEDBACK LINES
Good! Satelite 2 will pick up 2 more alphons to equal a charge of -3.

NEGATIVE FEEDBACK LINES
No. It will pick up 2 more alphons and change direction to equal -3.

Answer = -3

REMEDIAL PROBLEM # 20

```
EXHALE = True          CONSTANT =  2
SECONDS = 4                10's =  8

INNER = 1 2 3 4 5
OUTER = 4 3 2 1 0

           Satelite 1   Satelite 2
CHARGE =       1           -2
DISTANCE =    4.0         18.0
BLIP =
```

PROMPT LINES
What will be the charge of satelite 1 after 4 more seconds ?

POSITIVE FEEDBACK LINES
Better! Satelite 1 will pick up 2 more alphons to equal a charge of -3.

NEGATIVE FEEDBACK LINES
Still wrong. It will pick up 2 more and change direction to equal -3.

Answer = -3

PRACTICE PROBLEM # 21

```
EXHALE = False         CONSTANT =  2
SECONDS = 1                10's =  9

INNER = 1 2
OUTER = 3 2

           Satelite 1   Satelite 2
CHARGE =       1            2
DISTANCE =    2.0          8.0
BLIP =
```

PROMPT LINES
What will be the charge of satelite 2 after 3 more seconds ?

POSITIVE FEEDBACK LINES
Very good! Satelite 1 will blip first, then satelite 2, leaving both at 0.

NEGATIVE FEEDBACK LINES
Incorrect. Both satelites will drop off alphons to equal 0 charges.

Answer = 0

REMEDIAL PROBLEM # 21

```
EXHALE = False         CONSTANT =  2
SECONDS = 4                10's =  9

INNER = 1 2 3 4 5
OUTER = 3 2 2 3 2

           Satelite 1   Satelite 2
CHARGE =       1            1
DISTANCE =    4.0          2.0
BLIP =        2.0          3.0
```

PROMPT LINES
What will be the charge of satelite 1 after 2 more seconds ?

POSITIVE FEEDBACK LINES
Good! Same as before.. both sateli4es will drop their alphons to equal 0.

NEGATIVE FEEDBACK LINES
Still wrong. Same as before.. both will drop to charges of 0.

Answer = 0

PRACTICE PROBLEM # 22

EXHALE = True　　CONSTANT = 2
SECONDS = 1　　10's = 10

INNER = 7 6
OUTER = 1 2

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	2.0	6.0
BLIP =		

PROMPT LINES
What will be the charge of satelite 2 after 4 more seconds ?

POSITIVE FEEDBACK LINES
Excellent! After satelite 1 picks up 3, 2 more will be ready for satelite 2.

NEGATIVE FEEDBACK LINES
Nope. After satelite 1 picks up 3, satelite 2 will pick up 2 more.

Answer = -3

REMEDIAL PROBLEM # 22

EXHALE = True　　CONSTANT = 2
SECONDS = 6　　10's = 12

INNER = 2 3 4 5 6 7 0
OUTER = 5 4 3 2 1 0 0

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	4.0	4.0
BLIP =		

PROMPT LINES
What will be the charge of satelite 1 after 3 more seconds ?

POSITIVE FEEDBACK LINES
That's it! After satelite 2 picks up 2, 1 more will be ready for satelite 1.

NEGATIVE FEEDBACK LINES
Still wrong. After satelite 2 picks up 1, satelite 1 will pick up another.

Answer = -3

PRACTICE PROBLEM # 23

EXHALE = False　　CONSTANT = 2
SECONDS = 6　　10's = 16

INNER = 4 3 2 1 0 1 2
OUTER = 3 4 5 6 7 6 5

	Satelite 1	Satelite 2
CHARGE =	2	3
DISTANCE =	32.0	12.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Yes! Satelite 2 will drop off 2, leaving 4 in the outer section.

NEGATIVE FEEDBACK LINES
No. Satelite 2 will drop off 2, leaving 4 in the outer section.

Answer = 4

REMEDIAL PROBLEM # 23

EXHALE = False　　CONSTANT = 1
SECONDS = 0　　10's = 7

INNER = 3
OUTER = 4

	Satelite 1	Satelite 2
CHARGE =	-2	1
DISTANCE =	20.0	3.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Now you have it! Satelite 2 will drop off 1, leaving 2 after 3 seconds.

NEGATIVE FEEDBACK LINES
Still not there. Satelite 2 will drop off 1, leaving 2 after 3 seconds.

Answer = 2

PRACTICE PROBLEM # 24

EXHALE = True CONSTANT = 3
SECONDS = 3 10's = 7

INNER = 3 4 5 6
OUTER = 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	1	-1
DISTANCE =	15.0	3.0
BIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 6 seconds?

POSITIVE FEEDBACK LINES
Good! Satelite 1 will pick up 4, leaving only 1 after 6 more seconds.

NEGATIVE FEEDBACK LINES
Sorry. Satelite 1 will pick up 4, leaving only 1 after 6 more seconds.

Answer = 1

REMEDIAL PROBLEM # 24

EXHALE = True CONSTANT = 2
SECONDS = 0 10's = 8

INNER = 5
OUTER = 2

	Satelite 1	Satelite 2
CHARGE =	-1	2
DISTANCE =	30.0	6.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Much better! Satelite 2 will pick up 3, leaving only 2 after 3 more seconds.

NEGATIVE FEEDBACK LINES
Not yet. Satelite 2 will pick up 3, leaving only 2 after 3 more seconds.

Answer = 2

PRACTICE PROBLEM # 25

EXHALE = False CONSTANT = 2
SECONDS = 5 10's = 9

INNER = 3 2 1 0 1 2
OUTER = 1 2 3 4 3 2

	Satelite 1	Satelite 2
CHARGE =	2	1
DISTANCE =	4.0	4.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Very clever! Both satelites will drop off alphons, leaving 2 after 3 seconds.

NEGATIVE FEEDBCK LINES
That's wrong. Both satelites will drop off alphons, leaving 2 after 3 seconds.

Answer = 2

REMEDIAL PROBLEM # 25

EXHALE = False CONSTANT = 1
SECONDS = 6 10's = 5

INNER = 5 4 3 2 1 0 1
OUTER = 0 1 2 3 4 5 4

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	3.0	2.0
BLIP =		

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Yes! Both satelites will drop one alphon, leaving 3 after 3 more seconds.

NEGATIVE FEEDBACK LINES
Still wrong. Both will drop an alphon leaving 3 after 3 more seconds.

Answer = 3

PRACTICE PROBLEM # 26

```
EXHALE = True          CONSTANT =  1
SECONDS = 0                 10's =  6

INNER = 3
OUTER = 2

            Satelite 1   Satelite 2
CHARGE =        1            2
DISTANCE =     1.0          6.0
BLIP =
```

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 5 seconds?

POSITIVE FEEDBACK LINES
Very good! After both satelites drop of their alphons there will be 0.

NEGATIVE FEEDBACK LINES
Wrong. After both satelites drop off their alphons there will be 0 left.

Answer = 0

REMEDIAL PROBLEM # 26

```
EXHALE = True          CONSTANT =  2
SECONDS = 4                 10's =  6

INNER = 2 3 4 5 4
OUTER = 3 2 1 0 1

            Satelite 1   Satelite 2
CHARGE =        1            1
DISTANCE =     4.0          5.0
BLIP =
```

PROMPT LINES
How many alphons will be in the outer section of the nucleus after 3 seconds?

POSITIVE FEEDBACK LINES
Excellent! Satelite 1 will pick up 3 and satelite 2 will pick up 0.

NEGATIVE FEEDBACK LINES
Sorry. Satelite 1 will pick up 3 and leave 0 for satelite 2 to pick up.

Answer = 1

PRACTICE PROBLEM # 27

```
EXHALE = False         CONSTANT =  2
SCONDS = 5                  10's =  7

INNER = 2 1 0 1 2 3
OUTER = 7 8 9 8 7 6

            Satelite 1   Satelite 2
CHARGE =        2            1
DISTANCE =     8.0          17.0
BLIP =
```

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 5 more seconds ?

POSITIVE FEEDBACK LINES
Yes! It will make contact with the nucleus and return to 12.0 microns.

NEGATIVE FEEDBACK LINES
No. It will make contact with the nucleus and return to 12.0 microns.

Answer = 12.0

REMEDIAL PROBLEM # 27

```
EXHALE = False         CONSTANT =  1
SECONDS = 2                 10's =  8

INNER = 5 6 7
OUTER = 4 3 2

            Satelite 1   Satelite 2
CHARGE =       -2            1
DISTANCE =     24.0         1.0
BLIP =
```

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 3 more seconds ?

POSITIVE FEEDBACK LINES
That's right! It will make contact with the nucleus and return to 2.0.

NEGATIVE FEEDBACK LINES
Wrong again. It will make contact with the nucleus and return to 2.0.

Answer = 2.0

PRACTICE PROBLEM # 28

EXHALE = False CONSTANT = 1
SECONDS = 5 10's = 5

INNER = 3 2 1 0 1 2
OUTER = 3 4 5 6 5 4

	Satelite 1	Satelite 2
CHARGE =	4	-1
DISTANCE =	8.0	12.0
BLIP =		

PROLINES
How many microns from the nucleus will satelite 1 be after 7 more seconds ?

POSITIVE FEEDBACK LINES
Very good! After dropping 3 the charge will change to -1, ending at 5.0

NEGATIVE FEEDBACK LINES
Good try. After dropping 3 the charge will change to -1, ending up at 5.0.

Answer = 5.0

REMEDIAL PROBLEM # 28

EXHALE = False CONSTANT = 1
SECONDS = 3 10's = 7

INNER = 1 2 3 4
OUTER = 6 5 4 3

	Satelite 1	Satelite 2
CHARGE =	-1	5
DISTANCE =	16.0	10.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 10 more seconds ?

POSITIVE FEEDBACK LINES
Alright! After losing 2, it will move to 24.0 microns at 3 microns / second.

NEGATIVE FEEDBACK LINES
Sorry. After losing 2, it will move to 24.0 microns at 3 microns / second.

Answer = 24.0

PRACTICE PROBLEM # 29

EXHALE = False CONSTANT = 2
SECONDS = 5 10's = 10

INNER = 3 4 5 6 7 8
OUTER = 6 5 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	1	3
DISTANCE =	22.0	12.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 5 more seconds ?

POSITIVE FEEDBACK LINES
I'm impressed! After picking up 1, it will move at 8 microns/sec to 24.0.

NEGATIVE FEEDBACK LINES
I'm sorry. After picking up 1 alphon, it will move at 8 microns/sec to 24.0

Answer = 24.0

REMEDIAL PROBLEM # 29

EXHALE = True CONSTANT = 2
SECONDS = 8 10's = 11

INNER = 3 2 1 0 1 2 3 4 3
OUTER = 1 2 3 4 3 2 1 0 1

	Satelite 1	Satelite 2
CHARGE =	1	1
DISTANCE =	3.0	36.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 5 more seconds ?

POSITIVE FEEDBACK LINES
Excellent! After picking up 2 alphons it will move at 6 microns/sec to 21.0.

NEGATIVE FEEDBACK LINES
No. After picking up 2 alphons, it will move at 6 microns/sec to 21.0.

Answer = 21.0

PRACTICE PROBLEM # 30

EXHALE = False CONSTANT = 1
SECONDS = 0 10's = 13

INNER = 4
OUTER = 2

	Satelite 1	Satelite 2
CHARGE =	3	1
DISTANCE =	9.0	12.0
BLIP =		

PROMPT LINES
When will satelite 1 hit the nucleus ?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
That's Right! It will make contact
at 133.0 seconds.

NEGATIVE FEEDBACK LINES
That's wrong. It will hit at 133.0
seconds. Be sure to include the 10's.

Answer = 133.0

PRACTICE PROBLEM # 31

EXHALE = False CONSTANT = 1
SECONDS = 4 10's = 15

INNER = 0 1 2 3 4
OUTER = 5 4 3 2 1

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	5.0	10.0
BLIP =		

PROMPT LINES
When will satelite 1 hit the nucleus ?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
Very good! It will hit the nucleus
at 156.5 seconds.

NEGATIVE FEEDBACK LINES
Sorry. It will hit the nucleus at
156.5 seconds.

Answer = 156.5

REMEDIAL PROBLEM # 30

EXHALE = False CONSTANT = 1
SECONDS = 0 10's = 14

INNER = 2
OUTER = 3

	Satelite 1	Satelite 2
CHARGE =	-4	1
DISTANCE =	28.0	2.0
BLIP =		

PROMPT LINES
When will satelite 2 hit the nucleus ?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
Now you've got it! It will make
contact at 142.0 seconds.

NEGATIVE FEEDBACK LINES
Still wrong. It will make contact
at 142.0 seconds.

Answer = 142.0

REMEDIAL PROBLEM # 31

EXHALE = True CONSTANT = 2
SECONDS = 4 10's = 16

INNER = 0 1 2 3 4
OUTER = 4 3 2 1 0

	Satelite 1	Satelite 2
CHARGE =	2	-1
DISTANCE =	7.0	20.0
BLIP =		

PROMPT LINES
When will satelite 1 hit the nucleus ?
(to the nearest tenth of a second)

POSITIVE FEEDBACK LINES
That's it! It will make contact at
165.8 seconds.

NEGATIVE FEEDBACK LINES
Not quite. It will hit at 165.8 secs.
Be sure to round off to the tenth.

Answer = 165.8

PRACTICE PROBLEM # 32

EXHALE = False CONSTANT = 2
SECONDS = 3 10's = 17

INNER = 2 3 4 5
OUTER = 5 4 3 2

	Satelite 1	Satelite 2
CHARGE =	3	1
DISTANCE =	9.0	2.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 4 more seconds ?

POSITIVE FEEDBACK LINES
Remarkable!! Very few people could be expected to answer this correctly!

NEGATIVE FEEDBACK LINES
Good try! This is a tough one. It will be 10.0 microns away.

Answer = 10.0

REMEDIAL PROBLEM # 32

EXHALE = False CONSTANT = 2
SECONDS = 4 10's = 18

INNER = 1 0 1 2 3
OUTER = 5 6 5 4 3

	Satelite 1	Satelite 2
CHARGE =	2	2
DISTANCE =	10.0	4.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 5 more seconds ?

POSITIVE FEEDBACK LINES
Very good! Satelite 1 will hit the nucleus at 186.5 secs and move to 5.0.

NEGATIVE FEEDBACK LINES
Almost! Satelite 1 will hit the nucleus at 186.5 secs and move to 5.0.

Answer = 5.0

PRACTICE PROBLEM # 33

EXHALE = True CONSTANT = 1
SECONDS = 2 10's = 19

INNER = 9 8 7
OUTER = 0 1 2

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	1.0	3.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 2 be after 6 more seconds ?

POSITIVE FEEDBACK LINES
Very observant! Satelite 2 will not pick up alphons in moving to 9.0.

NEGATIVE FEEDBACK LINES
Sorry, satelite 2 will not pick up alphons as it moves to 9.0 microns.

Answer = 9.0

REMEDIAL PROBLEM # 33

EXHALE = True CONSTANT = 2
SECONDS = 6 10's = 20

INNER = 1 2 3 4 5 6 5
OUTER = 5 4 3 2 1 0 1

	Satelite 1	Satelite 2
CHARGE =	1	2
DISTANCE =	9.0	5.0
BLIP =		

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 7 more seconds ?

POSITIVE FEEDBACK LINES
Good job! Satelite 1 will pick up 3 more to reach 20.0 at 8 microns/sec.

NEGATIVE FEEDBACK LINES
no. Satelite 1 will pick up 3 more to reach 20.0 at 8 microns / second.

Answer = 20.0

PRACTICE PROBLEM # 34

```
EXHALE = True           CONSTANT =  2
SECONDS = 0                 10's = 22

INNER = 9
OUTER = 0

           Satelite 1   Satelite 2
CHARGE =        2            2
DISTANCE =    13.7          5.3
BLIP =
```

PROMPT LINES
How many microns from the nucleus will satelite 1 be after 6 more seconds ?

POSITIVE FEEDBACK LINES
AMAZING!! What genius! What luck ?!
YOU HAVE MASTERED XENOGRADE SYSTEMS !!

NEGATIVE FEEDBACK LINES
Don't feel too bad. It will be 20.6 microns from the nucleus. Good effort!

Answer = 20.6

REMEDIAL PROBLEM # 34

```
EXHALE = True           CONSTANT =  2
SECONDS = 0                 10's =  0

INNER = 0
OUTER = 0

           Satelite 1   Satelite 2
CHARGE =        0            0
DISTANCE =     0.0          0.0
BLIP =
```

PROMPT LINES
This completes today's activities (Press ENTER)...

POSITIVE FEEDBACK LINES
THANK YOU.

NEGATIVE FEEDBACK LINES
THANK YOU.

Answer = 0
