FLEXIBLE DISCUSSION UNDER STUDENT CONTROL IN THE ELIZA COMPUTER PROGRAM

Coordination of Small Discussion Units Illustrated in a Tutorial Discussion of the Train Paradox of Special Relativity

by

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ABSTRACT

Discussion of a physics problem between the student and a large general-purpose time-shared computer is carried out using the ELIZA program. The specific problem programmed for discussion is the train paradox of special relativity. Sub-programs, called scripts, tell the computer how to carry out the conversation. The scripts for the train paradox were written with two purposes in mind: (1) to teach the student some basic ideas of special relativity by discussing a specific problem; (2) to develop techniques of carrying on a tutorial conversation which will also be helpful in writing scripts for other problems. This thesis is mainly concerned with a description of the techniques developed for carrying on a tutorial conversation.

Three shortcomings of the present ELIZA system were considered as explained in the following paragraphs, and remedies developed which should be useful in a variety of subject contexts.

First, conversations using ELIZA have tended to be linear in the sense that the student is forced to follow prescribed and predetermined lines of argument. By dividing the subject matter into small independent topics of discussion, and providing a variable mechanism for controlling the order of these topics, a flexibility in directing the course of the conversation was achieved.

Second, the student has been bound by the scriptwriter's choice of approach to the problem. We have

developed a directing script that gives the student a choice among different approaches. The approaches all use the same individual topics, but differ in the way in which these topics are introduced in the conversation.

Third, the student has not had the ability to interrupt the conversation for any of several reasons, with the option of later returning to the point of interruption. In the course of discussing of the train paradox, the computer can recognize when the student wants to interrupt the conversation in order to change the approach, to ask a question, or to quit the discussion. Unless he quits the discussion, the student may return to the point at which the conversation was suspended. The supervisory mechanism can easily be extended to control interruptions for any number of other purposes.

THE ELIZA PROGRAM

The ELIZA program provides a method for carrying on a teletyped conversation in natural English between a student and a time-shared computer. The program was developed by Professor Joseph Weizenbaum of the MIT Department of Electrical Engineering. Technical details of the system at an earlier stage of its development have been published.[1] The present capabilities of the system are described in another paper.[2] A manual for users of the system is currently being written.[3] Briefly, ELIZA is based on a symmetric list processing computer language called SLIP (also developed by Professor Weizenbaum). SLIP provides a means for handling words and sentences by the computer. The basic method of analysis of student input is a search for specified <u>keywords</u> in this input, followed by attempts to match the input to a series of patterns called <u>decomposition rules</u> associated with the keywords. Information from the input can be saved for later use in lists called <u>reassembly lists</u>. ELIZA also has a context awareness, which makes it possible to use the same set of keywords, decomposition rules, and reassembly lists to analyze input in different contexts. For example, the computer can ask a series of questions and respond differently for each question, even if the answers are only yes or no. ELIZA employs a computer language called OPL (Online Programming Language) by which the scriptwriter instructs the computer to perform many different operations, including calculations, printing responses, storing and recording information, analyzing the input in an irregular manner, and changing the subject of conversation.

Each section of the present paper is divided into two parts. The first part, labeled "general", is a qualitative discussion designed to be understandable to the general reader. The second part, labeled "programming details", is written for those acquainted with the ELIZA program who wish to make practical use of the techniques described here.

SMALL UNITS OF DISCUSSION: General

The method of input analysis used by ELIZA makes it relatively easy to write scripts that maintain complete control of the conversation. The expected range of student response is limited by limiting the context of the discussion. Within this limited context, the scriptwriter must anticipate the statements of the student by careful selection of keywords and decomposition rules. Unanticipated student inputs are processed (or ignored) in a way that returns as quickly as possible to the prescribed line of argument. The result is a conversation which is linear and predetermined, and easy to program. Professor Edwin Taylor describes this linearity of pedagogic logic in the following manner:

> The student (whether he recognizes it or not) is herded down a narrow corridor of logic and is allowed to open only certain doors leading from the corridor. He opens one of these doors only to find himself in another equally narrow corridor.[4]

This is an undesirable situation, for the dialogue with the student should be dependent upon his needs and interests.

The basic approach developed in the discussion of the train paradox is to break the problem into small <u>units of discussion</u>. Each unit is contained in a single script, and consists of three or four interchanges between the student and the computer. The units, while small, are self-contained, so they may be ordered in any one of several ways. More will be said about ordering the units in the description of the method for directing the conversation.

The units of discussion for the train paradox are listed on page 48 in the Appendix. Since each unit is independent, more units can easily be added to supplement the present topics.

Within each unit, the context is limited to the subject of discussion. Since the course of the overall conversation is flexible, a linear, predetermined discussion of only three to four interchanges may be used within a unit. Thus, each unit of discussion is relatively easy to program, without losing overall flexibility.

There are two ways in which a given unit of discussion may be started. First, the end of the one unit may be reached in the course of conversation and the next appropriate unit determined. Then the new unit is called from disk storage and begun. Second, a new unit may be needed in the middle of another unit. Then the computer is instructed to remember where the original discussion stopped, and the new unit is called. When the new unit is finished, the original discussion may be resumed. Since the discussion units are independent, they may be used either sequentially or as sub-units of one another.

It is helpful to introduce the terms <u>level</u> and <u>sub-level</u> to characterize the method of using discussion units. Units are on the same level if they follow sequentially in the discussion in the first manner described above. Units are on a sub-level if they are used within another unit in the second manner described above. The two methods may be combined in a single discussion, and sub-levels of conversation used to any depth desired.

In the discussion of the train paradox, the use of units of discussion on different levels can be seen in Discussion 1 in the Appendix. Part of the conversation is shown diagrammatically below. The letters correspond to the last letters of the scripts which contain each discussion unit used.

```
top level              A——G——E——I         I——E——
                                  \       /
sub-level                          H     H
                                    \   /
sub sub-level                         J
```

The technique developed for controlling the introduction of each unit of discussion can handle a wide variety of structures of conversation. Particularly important is the fact that a discussion may continue on a sub-level through any number of units. When the conversation finally returns to the unit which was interrupted by going to the sub-level, it may return from a unit different from the first unit on the sub-level. A conceivable structure that demonstrates this is shown below.

```
top level              1——2                  2——8
                           \                /
sub-level                   3——4           4
                                \         /
sub sub-level                    5——6——7
```

The controlling mechanism is also independent of the subject of discussion, and can be used in the programming of tutorial conversations in a variety of subjects.

In order to prevent the discussion from repeating itself, the controlling mechanism checks to see if each new unit has been discussed previously. If it has, the student is told that he has already discussed the topic, and is asked whether or not he wishes to discuss it again. (This is not done if the discussion is returning from a sub-level to continue an interrupted unit.) If the student wants to discuss the topic again, the discussion of that topic is started. If he does not, the controlling mechanism continues as if he had already finished that topic.

SMALL UNITS OF DISCUSSION: Programming Details

As stated previously, each unit of discussion is contained in a single script. Thus, for this paper, the words _unit_ and _script_ are essentially synonomous. I will generally use the word _unit_ when describing the general approach and the word _script_ when describing the programming aspects.

It will also be helpful to note a distinction between the _controlling_ and _directing_ mechanisms, both of which are contained in TRAINE SCRIPT. The controlling mechanism governs the activation or _reading in_ of each script. Its operation is described in this section. The directing mechanism determines the ordering of the scripts, i.e., the overall course of the conversation. It is described in detail in the section Student Choice of Approach.

The ELIZA program provides three _groups_ or areas in which a script may be located in a _playable_ manner. (To _play_ a script, means to retrieve it from disk storage and to use it in directing a conversation.) The traffic of scripts into these groups is controlled in the following manner. TRAINE SCRIPT, which contains the controlling and directing mechanisms, is put into the first group ("group one") before the discussion begins. The script to be played is put into group two, and control is transferred to it. As each script is finished, control is transferred to a label called CHANGE in TRAINE SCRIPT, which reads the next script into group two, and transfers control to it. Group three is not used.

From the previous discussion of levels it is obvious that there are three ways in which a script may be called (or read in). (1) It may be called as the next script on the same level as the previous script. In this case, nothing special regarding the old script needs to be done. (2) It may be called as a sub-script as an interruption to another script. This time, the point of interruption must be remembered or stored. (3) From a sub-level, the interrupted script of the next higher level is called back in. The name and point of interruption must be located.

The mechanisms that control and differentiate these three cases are part of the program of each script. The controlling mechanism in TRAINE SCRIPT is located under the labels CHANGE, CHANG1, and CHANG2. The controlling mechanisms in all the scripts which contain units of discussion are located under the labels CHANGE, FINISH, and WHERE. They are identical in each such script. Certain identifiers or variables are used in these sections to make them independent of the particular scripts involved. SCRNAM is the name of the next script to be played, and PLACE is the label in that script to which control will be transferred. SUBSCR indicates whether or not the discussion is returning from a sub-level. If returning, i.e., case (3) above, SUBSCR is equal to one; if not, i.e., cases (1) and (2) above, SUBSCR is equal to zero. The list STORE keeps information regarding scripts that have been interrupted. This permits a return to these interrupted scripts at the correct label.

In case (1), SCRNAM and PLACE either may have been determined in the script just finished, or may be found in the directing mechanism in TRAINE SCRIPT. In the former case, they are set to new values somewhere within the old script, as determined by the course of the conversation. In TRAINA SCRIPT under label AE, for example, this occurs in the line:

PLACE='BEGIN, SCRNAM='TRAING, GOTO('CHANGE).

This takes place at point 1 in Conversation 1 in the Appendix. Control is transferred to CHANGE, which transfers control to CHANGE in TRAINE. In the latter case, when the end of the discussion of the old script has been reached, control is transferred to FINISH. STORE is empty because this case is on the top level. Control is then transferred to WHERE in TRAINE. This is the directing mechanism, which sets new values of SCRNAM and PLACE. Control is then transferred to CHANGE. Both cases are now identical. The new script, whose name is the value of SCRNAM, is read in and control is transferred to it at the label which is the value of PLACE.

In case (2), SCRNAM and PLACE for the sub-script are set in the old script. The label to which control should be transferred when the interrupted conversation is continued and the name of the old script are put as a pair in a list, which is put on the top of STORE. For example, this is done in TRAINI SCRIPT under label IA1:

```
*IA1      NEWTOP('(IB TRAINI),STORE),
          PLACE='BEGIN, SCRNAM='TRAINH, GOTO('CHANGE).
```

This occurs at point 2 in Conversation 1 in the Appendix. After the label and name are stored in this way, control is transferred to CHANGE, and the procedure becomes the same as in case (1).

In case (3), the conversation has reached an end on a sub-level of some undetermined depth, and control is transferred to FINISH in the old script. STORE has a list on it since the script is a sub-script. SUBSCR is set equal to one, and control is transferred to CHANGE, which transfers control to CHANGE in TRAINE. Since SUBSCR is equal to one, the top list is taken off STORE. There may be more lists in STORE, which would indicate higher levels, but it is only desired to return to the level which is one above the old one. The list which is taken off contains the name of the interrupted script and the label to go to in it, which are the new values of SCRNAM and PLACE, respectively. The script is read in and control transferred to it at the appropriate label as in the other cases. An example of this returning from a sub-level occurs at point 3 in Conversation 1 in the Appendix.

The section under CHANGE beginning with

```
PLAYED=ITSVAL(SCRNAM,PATH).
```

is used in all three cases. By the time control has been transferred here, SCRNAM and PLACE have their new values. This section governs the activation of the new script at the location specified. It first checks to see if the script has been played. The record of which scripts have been played is kept in the list NAMES, which is a description list of the list PATH. NAMES is a list of pairs, the first of which is the script name and the second of which is a value, zero if the script has not been played, one if it has been played. If the script has been played, the student is asked if he wants to discuss it again. If he does not, the discussion is in the position of having reached the end of whatever particular level he is on. Then, control is transferred to the label FINISH in the script which is in group two, to determine where to go from here. If he does want to discuss it again, control is transferred to CHANG2. The section under CHANG2 is used each time a script is begun. It records the transfer to the new script, and checks to see if the new script is already there, to save time reading it in again. Control is then transferred to the new script in the location indicated by PLACE.

It should be evident now why the scripts can be written as units of conversation independent of the level on which they may be used. When the end of a unit is reached, and the scriptwriter wants to continue the conversation as it has developed, control is transferred to FINISH. If the script is on a sub-level, there is a list on STORE which indicates case (3). If STORE is empty, the latter case of case (1) is indicated, so control is transferred to the directing mechanism in TRAINE. In the other cases, SCRNAM and PLACE are set to new values in the individual scripts, and the mechanism just continues the conversation. The use of identifiers in the controlling mechanisms, which are set to different values outside the mechanism, allow the controlling mechanism to be independent of the subject being discussed.

This completes the description of the controlling mechanism. By breaking the discussion into independent units and providing a controlling mechanism, a flexibility in the course of the conversation has been achieved. The use of units of discussion also forms the basis of the solution of the other pedagogic problems attacked.

STUDENT CHOICE OF APPROACH: General

The use of small units of discussion allows us to give the student a choice in the way he approaches the problem. In the discussion of the train paradox, the student is given a choice between three alternative approaches after the initial statement of the problem. The three approaches are: (1) the student may determine the topics of discussion himself from a list which is given him; (2) the student may let the computer lead the discussion; (3) the student may let the computer give some helpful hints aimed at usual misunderstandings of the problem. These are only three possibilities; others might be developed using the same units of discussion. The student also has the ability to change the approach at any time in the discussion. This ability will be described in the section Student Interruption of Conversation.

When the student makes his choice of approach, the computer is instructed to remember it. Each of the choices has its own mechanism to guide the course of the conversation. Initially, they set up the way in which the conversation will be guided. When the student reaches the end of a discussion unit on the top level, the mechanism appropriate to his choice then sets up the next unit of discussion. The controlling mechanism described previously is used to begin or continue the conversation.

STUDENT CHOICE OF APPROACH: Programming Details

The directing mechanism is located in TRAINE SCRIPT, and is contained in the program starting at the label CHOOSE and ending with the functions under the label WHERE1. The identifier or variable CHOICE is used to remember the student's choice. It is initially set to zero in TRAIN SCRIPT, and after the student has chosen an approach, has one of the values FREE, LEAD, or HINT, depending upon the approach chosen (approaches (1) to (3) respectively).

When the student first makes his choice, or when he changes it, control is transferred to the label CHOOS1, which records his choice and transfers control to the appropriate section for setting up the conversation. When the student reaches the end of a script on the top level of discussion (determined by the fact that STORE is empty), control is transferred to WHERE in TRAINE. Control is then transferred to the section that directs the discussion in the appropriate manner, depending upon the value of CHOICE, except in the case where TRSEND equals one, which indicates that the student has understood the problem. This case will be described in the section The Discussion of the Train Paradox. The determining mechanism sets new values for SCRNAM and PLACE. Then control is transferred to CHANGE, the controlling mechanism, which reads in the appropriate script and transfers control to it at the appropriate label.

Each of the three different approaches used in the discussion of the train paradox will now be discussed. The two important elements for each are initiating the conversation and directing it once started.

A. Student Freedom in Choosing Subjects

General

This approach gives the student the maximum amount of freedom to determine the subject of conversation. Initially, the student is given a list of the subjects which the individual scripts enable the computer to discuss. For the train paradox, this list is given at point 1 in Conversation 1 in the Appendix. The conversation is started with the unit that corresponds to his choice of subject. When the end of that subject is reached on the top level of conversation, the directing mechanism takes over again. Remembering that his choice of approach is for freedom in the selection of the subject, the computer asks him which subject he wants to discuss next, and the procedure is repeated.

Programming Details

The mechanism for this approach is contained in the section under the labels WHICH through WHICH3. Initially, the list of subjects that the computer can discuss are printed from the list SUBJCT. This is done under the label WHICH1. The student's choice is detected by the use of keywords and decomposition rules. The information regarding the appropriate script name and location are put in the reassembly list SEMBLY. This information is extracted under the label WHICH3, and control is transferred to CHANGE, which begins the discussion. If the conversation is continuing, only the section under the labels WHICH2 and WHICH3 are used to determine the student's choice of subjects.

B. Computer Led Discussion

General

When the student requests the computer to lead the discussion, the units of discussion are arranged in a logical order. Three major conceptual areas are distinguished for the discussion. They are the relativity of the frames of reference, the effect of the Lorentz contraction, and the simultaneity of events. Most units of discussion are associated with one of these three areas. The remainder would be used naturally at sub-levels of discussion in more than one subject area. If the student has already discussed and correctly understood any of these three basic concepts, the scripts associated with the understood concepts are not included in the ordering. The conversation follows this order until all the ordered units have been used, at which point the student is given the choice of either of the other two approaches to continue the discussion.

Programming Details

The units of discussion are arranged in order by putting the script names on the list PATH, under the label

MAP. The three conceptual areas are indicated by the identifiers or variables RLATIV, LENGTH, and TRSEND. If the value of the identifier is zero, the concept has not yet been understood, if the value of the identifier is one, the concept has been understood. The values are all initially set to zero, and are changed to one when in the course of conversation it is determined that the student understands the particular concept. If the computer led approach is the student's initial approach, all the concepts would be arranged for discussion. If the student has changed his approach, it is possible that he may already have discussed and understood a concept, in which case, the associated scripts are not put on the list PATH.

The script which is to be played is determined by the section under the label FOLLOW. SCRNAM is set by taking the next script name off the top of PATH. In each case, the discussion begins under the label START in the script, so PLACE is set to BEGIN. Control is then transferred to CHANGE, which will begin the discussion.

When the list PATH is found to be empty, the computer led discussion is at an end. Then the student is given a choice of either of the other two approaches to the problem. A list which contains O'E CHOOS1 is put on the top of the list TABLE. This insures that when he responds with his choice, control will be transferred to the label CHOOS1. The detection of his choice has already been described.

C. Hints Aimed at Usual Misunderstandings

General

If the student wishes to try to solve the problem without being led through it, but wants some help to get started, he may choose to proceed with some helpful hints. The hints are set up in order initially and each time the student has finished the unit of discussion which deals with a hint, the discussion continues with the next hint. In the discussion of the train paradox, the one hint is the unit of discussion which deals with the synchronization of watches. When all of the hints have been discussed, the student is asked to choose either of the other two approaches to continue the discussion.

Programming Details

The mechanism for handling the hints is located in TRAINE SCRIPT under the label HINT. The hints are set up in TRAIN SCRIPT by putting the identifier HINT1 in a list named HINTS. In TRAINE script, the hint is located under the label HINT1. Control is transferred to the appropriate label by taking the label off the top of the list HINTS. Under each of the hint labels, PLACE and SCRNAM are set to new values, and control is transferred to CHANGE, which will begin the discussion.

When the list HINTS is found to be empty, all the hints have been used. Then the student is given a choice of either of the other two approaches to the problem. A list that contains O'E CHOOS1 is put on the top of the list

TABLE. This insures that when the student responds with his choice, control will be transferred to the label CHOOS1. The detection of his choice has already been described.

STUDENT INTERRUPTION OF CONVERSATION: General

One of the major goals of the ELIZA system is to allow the student to control as much as possible the course of the tutorial dialogue. One of the problems with the early scripts written using the ELIZA program is that they force the student to keep to the line of thought determined in advance by the programmer. Even in the small units of discussion this could be a problem if the student did not have the ability to interrupt the conversation for his own purposes, with the option of returning later to the point of interruption.

In the discussion of the train paradox, the student can interrupt the conversation by typing the word <u>wait</u>. In all the scripts, this is a keyword which will override any condition of the conversation. The point of interruption is remembered by the computer, and the program tries to determine what the student wants to do. Since this aspect of scriptwriting is still being developed, the number of things which the student can presently do is limited. He may change his approach to the problem. He may ask a question about the graphs of the situation as viewed from the frame of reference of the train. (The technique of allowing the student to ask questions is also still being developed, which is why the student is limited to questions about the graphs.) He may go back to the point of interruption and continue the discussion from that point. Finally, he may quit and end the discussion.

The mechanism for analyzing what the student wants to do is located in the same area that the controlling and directing mechanisms are located. Thus, it will be easy to add additional abilities as they are developed. Some of the possibilities are: further development of the ability to ask questions, request definitions, and ask for explanations; recognizing that the computer is on the wrong track as far as the student's needs are concerned; and recognizing that the student has suddenly understood the immediate point that the computer has been discussing.

STUDENT INTERRUPTION OF CONVERSATION: Programming Details

The detection of the student's desire to interrupt the conversation is accomplished by using WAIT as a keyword, with a rank higher than any other keyword in the script, and high enough to override an O'E on the TABLE. This transfers control to the label WAIT in the individual scripts, which transfers control to the label WAIT in TRAINE SCRIPT in group one. In case the student indicated what he wanted to do when he typed wait, his input is processed according to the keywords of TRAINE SCRIPT, after removing the top word WAIT. All these keywords have a rank high enough to override the O'E which is put on the TABLE (which is done in case the student did not initially indicate his desire or the computer does not understand his request).

In order to return to the point of interruption, we need to know the script name and the last label used before the interruption. The small section in each unit script between PROG and START is used every time there is a transfer of control to a label (including labels resulting from processing an input). In this section the current label is stored under LABEL and the proceeding label is stored under SVLBL. When the student interrupts, the value of SVLBL is the last label used before interruption. The point of interruption is saved by using the identifiers OLDLBL and OLDNAM. OLDLBL is set to the value of of SVLBL. OLDNAM is set to the value of SCRNAM, the name of the script which has just been interrupted.

When the student indicates that he wants to go back to the point of interruption, control is transferred to the label GOBACK in TRAINE. SCRNAM and PLACE are set to the value of OLDNAM and OLDLBL, respectively, and control is transferred to CHANG2, which will call back the interrupted script and transfer control to it at the last label used in the conversation.

Since OLDNAM and OLDLBL are identifiers, and can save only one point of interruption at a time, the interrupt mechanism is not recursive. By using a list, which could save any number of interruptions, it could easily be made recursive.

The addition of more interruption abilities for the student could be carried out by adding the appropriate keywords, decomposition rules, and programming mechanisms to TRAINE SCRIPT. This centralization of the interruption mechanism is desirable in that additions have to be made to only one script, and not to all the unit discussions. This puts a limitation on the student, which is restrictive but reasonable, in that he must type <u>wait</u> in order to interrupt the conversation.

THE DISCUSSION OF THE TRAIN PARADOX: General

In the discussion of the train paradox, the student is presented with the problem and asked some questions about it to determine his understanding of the concept of simultaneity. The key question is: "Does E see the light signals simultaneously or at different times?" There is a branch in the framework of the discussion at this point depending upon the answer the student gives. After the conversation has progressed sufficiently far to present the nature of the paradox, the student is asked which approach he wishes to take in the discussion. The course of the conversation then proceeds according to his choice, as described previously. The main point of the discussion is to help the student understand that events which appear to occur simultaneously in one frame will not appear to occur simultaneously when viewed from a reference frame moving relative to the first. When it is apparent in the course of the conversation that the student understands this, an indicator in the program is set. The next time the student finishes a unit of discussion on the top level, he is asked if he wants to quit or to continue. The purpose of the discussion has actually been accomplished, but the student may wish to continue to discuss some minor aspect of the problem.

THE DISCUSSION OF THE TRAIN PARADOX: Programming Details

Most of the conversation in the units of discussion proceeds by the computer asking questions requiring short answers and then utilizing the TABLE mechanism of the ELIZA program to detect the answer given by the student. Most of the units are arranged in such a way that the discussion is aimed at the student who does not understand the idea which is contained in the unit of discussion. The student who does understand spends very little time in each unit. Conversation 2 in the Appendix is a good example of a conversation with a student who understands the paradox.

The indicator which is set to indicate that the student understands the paradox is the identifier TRSEND. It is initially set equal to zero, and is set equal to one when the student understands. When a discussion unit is finished on the top level, control is transferred to FINAL, and he is asked if he wants to quit or to continue. This is only done once, and if the student continues, the identifier FNL will have been set equal to one. Thus, after the first time, when control is transferred to FINAL it is then transferred back to WHERE1. If TRSEND is not equal to one, the conversation continues according to the student's choice of approach in the manner described previously.

CONCLUSION

In the course of developing the program presented in this thesis, parts of it were tried out by ten paid and volunteer students. Their answers and the difficulties they encountered were used to improve the unit scripts and to determine where the controlling scripts needed more versatility. Most changes can be made quickly and easily after use by each student. This kind of student participation is a powerful method for improving the coverage and quality of the units of discussion.

The discussion of the train paradox has been the example used to illustrate techniques for giving the student a fair amount of control over the course of a tutorial conversation. Units of discussion on the train paradox have not been fully developed, but the techniques of student control have been worked out in some detail. With these techniques the train paradox discussion could be completed or any number of other subjects discussed fully in a tutorial fashion.

FOOTNOTES

1. Joseph Weizenbaum, Communications of the ACM, Volume 9, Number 1, page 36, January 1966.

2. Edwin Taylor, The ELIZA Program: Conversational Tutorial, presented at convention of Institute of Electrical and Electronics Engineers, March 20, 1967. (Available at M.I.T. Education Research Center).

3. Paul Hayward, ELIZA Scriptwriter's Manual. Unpublished paper, (Available at M.I.T. Education Research Center).

4. Taylor, op. cit., p. 8.

APPENDIX: Example Discussions

This section contains discussions that were generated using the TRAIN scripts. They demonstrate the use of unit discussions as described in this paper. The script which is controlling the discussion is indicated to the right of the conversation. The computer part of the dialogue is represented by upper case letters. The student part of the dialogue is represented by lower case letters. In the original copy, the computer part of the dialogue is also represented by red type, except for computer printed graphs and derivations. In the discussion, the following conventions and notations are used:

```
*     means multiply
**    means raised to the power of
/     means divide
'     means prime, indicates train frame of reference.
      Unprimed quantities indicate ground frame
      of reference.
X     means position
T     means time
V     means velocity
C     means speed of light, a constant
B     means beta      B = V/C
G     means gamma     G = 1/((1-B**2)**(1/2))
      in other words: gamma equals 1 divided
      by the square root of quantity (1 - beta squared).
```

DISCUSSION 1

```
r system
W 2136.0
WHICH SCRIPT PLEASE
train
TRAIN SCRIPT. A DISCUSSION OF THE TRAIN PARADOX    • TRAIN
OF SPECIAL RELATIVITY.                                initializes
PLEASE TYPE YOUR NAME, YOUR YEAR, YOUR COURSE,     • TRAINA
AND WHETHER YOU HAVE TAKEN, HAVE NOT TAKEN, OR        top level
ARE TAKING 8.02 .
Paul R. Hayward, senior, physics#, have taken 8.02

OBSERVERS D, E, AND F ARE RIDING IN A TRAIN
WHICH IS TRAVELLING TO THE RIGHT WITH A
CONSTANT RELATIVISTIC VELOCITY V WITH RESPECT
TO THE FRAME OF REFERENCE OF OBSERVERS A, B,
AND C, WHO ARE AT REST WITH RESPECT TO THE
GROUND. CONSIDER BOTH FRAMES AS INERTIAL FRAMES
OF REFERENCE. B IS HALFWAY BETWEEN A AND C, AND
E IS HALFWAY BETWEEN D AND F. WHEN D PASSES A,
A FLASHES A SINGLE LIGHT SIGNAL TOWARD B. WHEN
F PASSES C, C FLASHES A SINGLE LIGHT SIGNAL
TOWARD B. ASSUME THAT THE DISTANCE BETWEEN A
AND C IS SUCH THAT ACCORDING TO THE
SYNCHRONIZED WATCHES OF A AND C, D PASSES A AT
THE SAME TIME THAT F PASSES C.

 GRAPH    ONE      05/16  2146.6

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT
TO THE GROUND AND OBSERVERS A, B, AND C.  AT THE TIME WHEN
THE LIGHT SIGNALS ARE EMITTED.  * INDICATES THE LIGHT SIGNALS,
AND - INDICATES THEIR DIRECTION OF TRAVEL.

       TRAIN    D=========E=========F    V (TO THE RIGHT)
LIGHT SIGNAL    *-                  -*
      GROUND    A.........B.........C

WILL B SEE THE SIGNALS SIMULTANEOUSLY OR AT
DIFFERENT TIMES.
he will see the signals at the same time
```

CORRECT. NOW IF E IS ALSO ABLE TO SEE THE LIGHT SIGNALS, WILL HE OBSERVE THEM SIMULTANEOUSLY OR AT DIFFERENT TIMES.
he will also observe them at the same time

POINT 1
• TRAING
top level

WHAT ARE YOUR REASONS FOR SAYING THAT E WILL SEE THE SIGNALS SIMULTANEOUSLY.
because of symmetry

AS A MATTER OF FACT, E WILL NOT SEE THE SIGNALS SIMULTANEOUSLY. SINCE E IS TRAVELLING TOWARD THE LIGHT SIGNAL FROM C AND AWAY FROM THE LIGHT SIGNAL FROM A, HE WILL SEE THE SIGNAL FROM C FIRST.
WOULD YOU LIKE THIS SHOWN BY GRAPHS.
yes please

GRAPH TWO 05/16 2210.4

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT TO THE GROUND AND OBSERVERS A, B, AND C. AT THE TIME WHEN THE LIGHT SIGNALS HAVE TRAVELLED PART WAY TO B.

```
       TRAIN       D=========E=========F    V (TO THE RIGHT)
LIGHT SIGNAL         *-        -*
      GROUND    A.........B.........C
```

GRAPH THREE 05/16 2211.6

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT TO THE GROUND AND OBSERVERS A, B, AND C. AT THE TIME WHEN THE LIGHT SIGNALS HAVE ARRIVED AT B.

```
       TRAIN          D=========E=========F    V (TO THE RIGHT)
LIGHT SIGNAL             -*-
      GROUND    A.........B.........C
```

WHAT DON'T YOU UNDERSTAND ABOUT THIS PROBLEM.
why b doesn't see the signals at different times
if e does

IN OUR DISCUSSION, YOU HAVE A CHOICE OF THE TYPE OF APPROACH TO THE PROBLEM WHICH WE WILL FOLLOW.
YOU MAY DETERMINE THE TOPICS OF DISCUSSION YOURSELF FROM A LIST OF TOPICS I WILL GIVE YOU, OR YOU MAY LET ME LEAD THE DISCUSSION, OR YOU MAY TRY TO SOLVE THE PROBLEM WITH THE AID OF SOME HELPFUL HINTS FROM ME. AT ANY TIME, YOU MAY CHANGE THIS CHOICE BY INTERRUPTING THE CONVERSATION AND TELLING ME YOU WANT TO CHANGE YOUR APPROACH. WHAT IS YOUR INITIAL CHOICE.

• TRAINE
directing

I want to determine the topics myself

WE CAN DISCUSS ANY OF THE FOLLOWING TOPICS.
THE RELATIVITY OF THE FRAMES OF REFERENCE.
DIFFERENCES IN THE SITUATION WHEN VIEWED FROM THE FRAME OF REFERENCE OF THE TRAIN RATHER THAN THE GROUND.
MEASUREMENT OF LENGTH.
SYNCHRONIZATION OF WATCHES.
SIMULTANEITY OF EVENTS.
THE CONDITIONS WHICH DETERMINE THE EMISSION OF THE LIGHT SIGNALS.
GRAPHS OF THE EVENTS AS VIEWED FROM THE GROUND FRAME OF REFERENCE.
GRAPHS OF THE EVENTS AS VIEWED FROM THE TRAIN FRAME OF REFERENCE.
WHICH OF THE SUBJECTS WOULD YOU LIKE TO DISCUSS.

the simultaneity of events

IS IT TRUE THAT 'SIMULTANEITY' HAS A MEANING WHICH IS DIFFERENT IN THE TRAIN FRAME AND IN THE GROUND FRAME.

• TRAINI
top level

no

CONSIDER THE FOLLOWING DERIVATION.

EQN ONE 05/16 2220.0

FROM THE LORENTZ TRANSFORMATION EQUATIONS, I WILL SHOW THAT EVENTS WHICH ARE SIMULTANEOUS IN THE GROUND FRAME OF REFERENCE ARE NOT SIMULTANEOUS IN THE TRAIN FRAME OF REFERENCE.

WE WANT T' IN TERMS OF X AND T . IN OTHER WORDS, WE WANT THE TRANSFORMATION EQUATION THAT RELATES TIME IN THE TRAIN FRAME TO POSITION AND TIME IN THE GROUND FRAME.
THAT EQUATION IS:

```
    T' = G * (T - (B * X)/C)
```

ASSUME THAT THE POSITION OF OBSERVER A IS X = 0
AND THAT THE POSITION OF OBSERVER C IS X = L
SINCE A AND C HAVE SYNCHRONIZED WATCHES, WE CAN SET T = 0 AT X = 0 AND AT X = L .
PUT THIS INTO THE FORMULA:

```
  AT X = 0 AND T = 0
     T' = G * (0 - (B * 0)/C)
     T' = 0

  AT X = L AND T = 0
     T' = G * (0 - (B * L)/C)
     T' = - (G * B * L)/C
     T' = - (3/4) * (L/C)     SINCE B = 3/5 AND G = 5/4
```

THUS, TWO EVENTS WHICH OCCUR AT THE SAME TIME IN THE GROUND FRAME, ARE OBSERVED TO OCCUR AT DIFFERENT TIMES IN THE FRAME OF THE TRAIN. DO YOU UNDERSTAND THIS NOW.

no

I HAVE SAID THAT A AND C HAVE SYNCHRONIZED WATCHES. WOULD IT BE POSSIBLE TO SYNCHRONIZE THE WATCHES OF A AND D TO READ THE SAME TIME.

POINT 2
• TRAINH
sub-level

yes, why not

HOW WOULD YOU DO THIS.

the same way that you synchronized the watches of a and c

IF THEY ARE SYNCHRONIZED AT ONE SPECIFIC TIME,
WILL THEY REMAIN SYNCHRONIZED FOR LATER TIMES.
yes, why not

WRONG. CONSIDER THE LORENTZ TRANSFORMATION
EQUATION-
T'=G*T-(B*X)/C
X CAN BE THE POSITION OF OBSERVER A IN THE
GROUND FRAME. THIS REMAINS FIXED. AS T
INCREASES, T' WILL INCREASE BY A FACTOR OF G.
WHICH FRAME DOES THIS ARGUMENT TAKE TO BE
STATIONARY.
the train frame

COULD THE SAME EQUATION BE USED TAKING THE
TRAIN FRAME TO BE STATIONARY, AND SOLVING FOR
T.
yes

WRONG. LET'S CONSIDER THE PRINCIPLE OF
RELATIVITY FOR A MINUTE.
WOULD IT HAVE MADE ANY DIFFERENCE IN THE
DISCUSSION OF THE PROBLEM IF THE GROUND FRAME
HAD BEEN DESCRIBED AS ANOTHER TRAIN FRAME-

• TRAINJ
sub sub-level

GRAPH TEN 05/16 2225.5

IN THE FRAME OF TRAIN2.

```
      TRAIN1      D=========E=========F      V (TO THE RIGHT)
LIGHT SIGNAL      *-                 -*
      TRAIN2      A.........B.........C
```

WITHOUT ANY REFERENCE TO THE RELATIONSHIP OF
THESE FRAMES TO THE EARTH FRAME.
no

RIGHT.
AS FAR AS THE PROBLEM IS CONCERNED, THE GROUND
FRAME SHOULD BE CONSIDERED AS AN INERTIAL FRAME
WITH NO SPECIAL QUALITIES.
LET'S GO BACK TO THE ARGUMENT RELATING T AND
T'.
WHICH FRAME DOES THIS ARGUMENT TAKE TO BE
STATIONARY.
I see now. If the equation was solved for T,
the two equations would not be symmetric.
The stationary frame in this case is the
ground frame.

POINT 3

• TRAINH
return to
sub level

CORRECT.
THEN THE WATCHES OF A AND D CANNOT BE SYNCHRONIZED.
WHAT IF D AND F AGREE THAT TWO EVENTS OCCUR SIMULTANEOUSLY IN THE TRAIN FRAME. WOULD A AND C OBSERVE THEM SIMULTANEOUSLY.
no

• TRAINI
return to
top level

SO WE HAVE SEEN THAT MEASURED TIME IS DIFFERENT IN DIFFERENT INERTIAL FRAMES OF REFERENCE.
WE HAVE REACHED THE END OF THIS LINE OF THOUGHT.
YOU SEEM TO UNDERSTAND THE BASIC IDEA WHICH THIS DISCUSSION HAS BEEN AIMED AT, NAMELY, THAT SEPARATED EVENTS WHICH ARE VIEWED TO OCCUR AT THE SAME TIME IN ONE FRAME OF REFERENCE WILL NOT BE VIEWED TO OCCUR SIMULTANEOUSLY IN A FRAME MOVING RELATIVE TO THE FIRST. WOULD YOU LIKE TO CONTINUE THE DISCUSSION OR WOULD YOU LIKE TO QUIT.
I would like to continue

• TRAINE
directing

WHICH OF THE SUBJECTS WOULD YOU LIKE TO DISCUSS.
the measurement of length

• TRAIND
top level

IN GRAPH ONE, THE DISTANCE AC APPEARS TO BE EQUAL TO THE DISTANCE DF. IN WHICH FRAME OR FRAMES OF REFERENCE IS THIS TRUE.
in both the train and ground frames

DO YOU UNDERSTAND THE LORENTZ CONTRACTION
yes

DO YOU SEE WHY THE LORENTZ CONTRACTION WILL MAKE THE DISTANCES APPEAR TO BE UNEQUAL WHEN MEASURED IN THE TRAIN FRAME.
no

WOULD YOU LIKE TO HAVE THIS EXPLAINED BY GRAPHS, BY EQUATIONS, OR BY DISCUSSION.
by graphs

```
 GRAPH   NINE      05/16  2236.4

AS VIEWED FROM THE GROUND FRAME OF REFERENCE,
IT APPEARS AS IF AC = DF.

 TRAIN     D=========E=========F      V (TO THE RIGHT)
GROUND     A.........B.........C

BUT DF IS CONTRACTED BY A FACTOR OF GAMMA
COMPARED TO ITS REST LENGTH, SINCE IT IS
MOVING WITH RESPECT TO THE GROUND FRAME.

THE FOLLOWING WOULD BE THE SITUATION IF THE
TRAIN WERE NOT MOVING WITH RESPECT TO THE
GROUND FRAME, A COMPARISON OF THE REST LENGTHS.

 TRAIN     D============E============F    NO RELATIVE
GROUND        A.........B.........C          VELOCITY

BUT THIS IS NOT THE SITUATION DESCRIBED IN THE PROBLEM.
IN THE TRAIN FRAME, THE DISTANCE AC WILL APPEAR TO BE
CONTRACTED BY A FACTOR OF GAMMA COMPARED WITH ITS
REST LENGTH.  THE DISTANCE DF WILL BE ITS REST LENGTH.

 TRAIN     D============E============F
GROUND          A.......B.......C         V (TO THE LEFT)

WOULD YOU LIKE TO SEE GRAPHS OF THE SITUATION    • TRAINB
AS SEEN FROM THE FRAME OF REFERENCE OF THE          top level
TRAIN.
yes


 GRAPH   FOUR      05/16  2241.0

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT
TO THE TRAIN AND OBSERVERS D, E, AND F.  AT THE TIME WHEN
THE LIGHT SIGNAL FROM C IS EMITTED.

       TRAIN              D============E============F
LIGHT SIGNAL                                       -*
      GROUND                        A.......B.......C  V (TO THE LEFT)

SHALL I CONTINUE WITH THE NEXT GRAPH.            • interruption
yes
```

```
 GRAPH   FIVE      05/16  2243.0

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT
TO THE TRAIN AND OBSERVERS D, E, AND F.  AT THE TIME WHEN
THE LIGHT SIGNAL FROM C IS OBSERVED BY E.

       TRAIN             D============E============F
LIGHT SIGNAL                         -*
      GROUND               A.......B.......C      V (TO THE LEFT)

SHALL I CONTINUE WITH THE NEXT GRAPH.
yes


 GRAPH    SIX      05/16  2243.8

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT
TO THE TRAIN AND OBSERVERS D, E, AND F.  AT THE TIME WHEN
THE LIGHT SIGNAL FROM A IS EMITTED.

       TRAIN             D============E============F
LIGHT SIGNAL             *-       -*
      GROUND             A.......B.......C     V (TO THE LEFT)

SHALL I CONTINUE WITH THE NEXT GRAPH.
yes


 GRAPH  SEVEN      05/16  2244.6

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT
TO THE TRAIN AND OBSERVERS D, E, AND F.  AT THE TIME WHEN
THE LIGHT SIGNALS MEET.

       TRAIN             D============E============F
LIGHT SIGNAL                 -*-
      GROUND          A.......B.......C         V (TO THE LEFT)

SHALL I CONTINUE WITH THE NEXT GRAPH.
wait, i want to ask you a question

WHAT DON'T YOU UNDERSTAND ABOUT GRAPH SEVEN     • TRAINC
why does b see the signals at the same time        top level
when we look at the situation from the
train frame
```

AS VIEWED FROM THE FRAME OF REFERENCE OF THE GROUND, B SEES THE LIGHT SIGNALS SIMULTANEOUSLY. THIS CAN BE THOUGHT OF AS A SINGLE EVENT-THE EXISTENCE OF THE TWO LIGHT SIGNALS AND B AT A SINGLE POINT IN SPACE AND TIME. IN THE TRAIN FRAME, THIS WILL STILL BE A SINGLE EVENT.
I see, please continue with the graphs

AS I WAS SAYING,

- TRAINE
  going back
- TrainB
  top level

GRAPH EIGHT 05/16 2252.4

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT TO THE TRAIN AND OBSERVERS D, E, AND F. AT THE TIME WHEN THE LIGHT SIGNAL FROM A IS OBSERVED BY E.

```
      TRAIN              D============E============F
LIGHT SIGNAL     -*                   *-
      GROUND    A.......B.......C                              V (TO THE LEFT)
```

SHALL I CONTINUE WITH THE NEXT GRAPH.
yes

THESE ARE ALL THE GRAPHS. DO YOU UNDERSTAND NOW WHY THE LIGHT SIGNALS APPEAR TO BE EMITTED AT DIFFERENT TIMES IN THE FRAME OF REFERENCE OF THE TRAIN.
yes

VERY GOOD. WE HAVE ACCOMPLISHED THE PURPOSE OF THIS CONVERSATION.
WHICH OF THE SUBJECTS WOULD YOU LIKE TO DISCUSS.
wi@wait, I am ready to quit now

- TRAINE
  directing
- interruption

THANK YOU FOR YOUR ATTENTION. I HOPE THAT I HAVE BEEN ABLE TO HELP YOU.
R 170.883+83.166

- quit

DISCUSSION 2

```
r system
W 2101.1
WHICH SCRIPT PLEASE
train
TRAIN SCRIPT. A DISCUSSION OF THE TRAIN PARADOX    • TRAIN
OF SPECIAL RELATIVITY.                                 initializes
PLEASE TYPE YOUR NAME, YOUR YEAR, YOUR COURSE,     • TRAINA
AND WHETHER YOU HAVE TAKEN, HAVE NOT TAKEN, OR         top level
ARE TAKING 8.02 .
Paul R. Hayward, senior, physics, have taken 8.02

OBSERVERS D, E, AND F ARE RIDING IN A TRAIN
WHICH IS TRAVELLING TO THE RIGHT WITH A
CONSTANT RELATIVISTIC VELOCITY V WITH RESPECT
TO THE FRAME OF REFERENCE OF OBSERVERS A, B,
AND C, WHO ARE AT REST WITH RESPECT TO THE
GROUND. CONSIDER BOTH FRAMES AS INERTIAL FRAMES
OF REFERENCE. B IS HALFWAY BETWEEN A AND C, AND
E IS HALFWAY BETWEEN D AND F. WHEN D PASSES A,
A FLASHES A SINGLE LIGHT SIGNAL TOWARD B. WHEN
F PASSES C, C FLASHES A SINGLE LIGHT SIGNAL
TOWARD B. ASSUME THAT THE DISTANCE BETWEEN A
AND C IS SUCH THAT ACCORDING TO THE
SYNCHRONIZED WATCHES OF A AND C, D PASSES A AT
THE SAME TIME THAT F PASSES C.

 GRAPH    ONE      05/16  2108.2

FROM THE FRAME OF REFERENCE WHICH IS STATIONARY WITH RESPECT
TO THE GROUND AND OBSERVERS A, B, AND C.  AT THE TIME WHEN
THE LIGHT SIGNALS ARE EMITTED.  * INDICATES THE LIGHT SIGNALS,
AND - INDICATES THEIR DIRECTION OF TRAVEL.

       TRAIN    D=========E=========F    V (TO THE RIGHT)
LIGHT SIGNAL    *-                  -*
      GROUND    A.........B.........C

WILL B SEE THE SIGNALS SIMULTANEOUSLY OR AT
DIFFERENT TIMES.
simultaneously

CORRECT. NOW IF E IS ALSO ABLE TO SEE THE LIGHT
SIGNALS, WILL HE OBSERVE THEM SIMULTANEOUSLY OR
AT DIFFERENT TIMES.
at different times

WHICH SIGNAL WILL E SEE FIRST.
the signal from c
```

YOU'RE RIGHT. BUT LET'S EXAMINE ANOTHER
POSSIBLE ANSWER. ONE STUDENT SAYS-
IN THE FRAME OF REFERENCE OF THE TRAIN, THE
TRAIN APPEARS TO BE AT REST AND THE GROUND
APPEARS TO BE MOVING WITH A VELOCITY V TO THE
LEFT. D AND F SEE THE LIGHT SIGNALS EMITTED AT
THE SAME TIME ACCORDING TO THEIR SYNCHRONIZED
WATCHES. THE SPEED OF LIGHT IS INDEPENDENT OF
THE SOURCE VELOCITY AND EQUAL TO THE CONSTANT C
IN ALL INERTIAL FRAMES OF REFERENCE, AND THE
DISTANCES DE AND EF ARE EQUAL. THEREFORE, E
WILL SEE THE SIGNAL FROM A BEFORE THE SIGNAL
FROM C, SINCE B WILL BE TRAVELLING TOWARD THAT
SIGNAL.
THIS OBVIOUSLY CONTRADICTS YOUR ANSWER. WHAT IS
WRONG WITH THIS ANALYSIS.
the signals are not emitted at the same time

WHICH FRAME OF REFERENCE ARE YOU VIEWING THE
SITUATION FROM.
the frame of the train

CORRECT. IN THE FRAME OF REFERENCE OF THE
TRAIN, THE SIGNALS ARE NOT EMITTED AT THE SAME
TIME.
WE HAVE REACHED THE END OF THIS LINE OF
THOUGHT.

• TRAINE
directing

YOU SEEM TO UNDERSTAND THE BASIC IDEA WHICH
THIS DISCUSSION HAS BEEN AIMED AT, NAMELY, THAT
SEPARATED EVENTS WHICH ARE VIEWED TO OCCUR AT
THE SAME TIME IN ONE FRAME OF REFERENCE WILL
NOT BE VIEWED TO OCCUR SIMULTANEOUSLY IN A
FRAME MOVING RELATIVE TO THE FIRST. WOULD YOU
LIKE TO CONTINUE THE DISCUSSION OR WOULD YOU
LIKE TO QUIT.
I would like to continue the discussion

IN OUR DISCUSSION, YOU HAVE A CHOICE OF THE
TYPE OF APPROACH TO THE PROBLEM WHICH WE WILL
FOLLOW.
YOU MAY DETERMINE THE TOPICS OF DISCUSSION
YOURSELF FROM A LIST OF TOPICS I WILL GIVE YOU,
OR YOU MAY LET ME LEAD THE DISCUSSION, OR YOU
MAY TRY TO SOLVE THE PROBLEM WITH THE AID OF
SOME HELPFUL HINTS FROM ME. AT ANY TIME, YOU
MAY CHANGE THIS CHOICE BY INTERRUPTING THE
CONVERSATION AND TELLING ME YOU WANT TO CHANGE
YOUR APPROACH. WHAT IS YOUR INITIAL CHOICE.
I will let you lead the discussion

LET'S DISCUSS THE FOLLOWING.
WOULD IT HAVE MADE ANY DIFFERENCE IN THE DISCUSSION OF THE PROBLEM IF THE GROUND FRAME HAD BEEN DESCRIBED AS ANOTHER TRAIN FRAME-

• TRAINJ top level

```
 GRAPH    TEN      05/16  2124.3

IN THE FRAME OF TRAIN2.

      TRAIN1     D=========E=========F     V (TO THE RIGHT)
LIGHT SIGNAL     *-                 -*
      TRAIN2     A.........B.........C
```

WITHOUT ANY REFERENCE TO THE RELATIONSHIP OF THESE FRAMES TO THE EARTH FRAME.
no

RIGHT.
AS FAR AS THE PROBLEM IS CONCERNED, THE GROUND FRAME SHOULD BE CONSIDERED AS AN INERTIAL FRAME WITH NO SPECIAL QUALITIES.
WE HAVE REACHED THE END OF THIS LINE OF THOUGHT.

• TRAINE directing

LET'S DISCUSS THE FOLLOWING.
CONSIDER THE EMISSION OF THE LIGHT SIGNALS.
WHAT IS THE CONDITION WHICH DETERMINES WHEN A WILL SEND THE LIGHT SIGNAL TOWARD B.

• TRAINF top level

what do you mean by condition

IN OTHER WORDS, HOW WILL A KNOW WHEN TO FLASH HIS SIGNAL TOWARD B.
when d passes a

WHEN WILL C KNOW WHEN TO FLASH HIS SIGNAL TOWARD B.
when f passes c

WE HAVE REACHED THE END OF THIS LINE OF THOUGHT.

• TRAINE directing

LET'S DISCUSS THE FOLLOWING.
IN GRAPH ONE, THE DISTANCE AC APPEARS TO BE EQUAL TO THE DISTANCE DF. IN WHICH FRAME OR FRAMES OF REFERENCE IS THIS TRUE.

• TRAIND top level

wait

WHAT DO YOU WANT TO DO.
I want to change my approach

• TRAINE interruption

WHICH APPROACH DO YOU WANT TO CHANGE TO. • directing
let me see your helpful hints

LET'S CONSIDER THE FOLLOWING.
I HAVE SAID THAT A AND C HAVE SYNCHRONIZED • TRAINH
WATCHES. WOULD IT BE POSSIBLE TO SYNCHRONIZE top level
THE WATCHES OF A AND D TO READ THE SAME TIME.
no

CORRECT.
WE HAVE REACHED THE END OF THIS LINE OF • TRAINE
THOUGHT. directing
I HAVE GIVEN YOU ALL THE HELPFUL HINTS I HAVE.
WOULD YOU LIKE TO DETERMINE THE COURSE OF
CONVERSATION YOURSELF, OR HAVE THE DISCUSSION
LED BY ME.
wait

WHAT DO YOU WANT TO DO. • interruption
I am ready to quit

THANK YOU FOR YOUR ATTENTION. I HOPE THAT I
HAVE BEEN ABLE TO HELP YOU.
R 65.600+27.700 • quit

APPENDIX: The Program

This section contains the scripts which tell the computer how to carry on the tutorial discussion of the train paradox. The topics of discussion or the primary functions of the individual scripts are listed below.

Units of Discussion for the Train Paradox

TRAINA SCRIPT	statement of the problem and questions to determine the student's understanding.
TRAINB SCRIPT	graphs of the events as viewed from the train frame of reference.
TRAINC SCRIPT	answers certain questions about the graphs of the events as viewed from the train frame.
TRAIND SCRIPT	measurement of length and the lorentz contraction.
TRAINF SCRIPT	conditions that determine the time of emission of the light signals.
TRAING SCRIPT	graphs of the events as viewed from the ground frame of reference.
TRAINH SCRIPT	the synchronization of watches.
TRAINI SCRIPT	the simultaneity of events.
TRAINJ SCRIPT	relativity of the frames of reference.
TRAINK SCRIPT	the differences in the situation as described from the frame of reference of the train rather than the ground frame.

Other Scripts Used in the Conversation

TRAIN SCRIPT	initializes indicators and sets up necessary mechanisms.
TRAINE SCRIPT	controlling and directing mechanisms.
TRAINL SCRIPT	used for some minor initial details.

```
(PROG      (TRAIN
           IF(LEMPTY(INPUT))
             ( INPUT='(TRAIN SCRIPT-REVISED 5/16/67) )
             'NEXT ,
           GOTO(POPTOP(DAHIN)).
:WITH PRESENT SETUP, TRAIN MUST START IN GROUP ONE:
*START     IF(GROUP .NE. '1)
             ( SCRIPT(SA,'TRAIN),
               GROUP='1 ,
               NEWTOP('BEGIN,DAHIN) . )
             'NEXT ,
:INITIALIZATION OF SCRIPT PARAMETERS:
           STOUT='(CLOSE APPEND CONCAT DISK TRAIN OUT
             NWORD 8),
           STOUTN='(CLOSE APPEND CONCAT NOTYPE DISK TRAIN OUT
             NWORD 8),
           NUMBER='(FOUR FIVE SIX SEVEN EIGHT),
           GRPRNT='(PRINT GRAPH FOUR),
           LIST(TUPNI), LIST(PMOCED), LIST(YLBMES), LIST(ELBAT),
           LIST(STORE), LIST(FRAME), LIST(ESEE),
           LIST(SM), LIST(LC),
           J=1 , SUBSCR=0 , NKFLAG=0 , TIME=0 , X=0 ,
           TRSEND=0 , LENGTH=0 , RLATIV=0 ,
           LIST(PATH), CHOICE=0 , FNL=0 ,
           NAMES='(TRAINA 0 TRAINB 0 TRAINC 0 TRAIND 0
             TRAINF 0 TRAING 0 TRAINH 0 TRAINI 0
             TRAINJ 0 TRAINK 0 TRAINM 0 ),
           MAKEDL(NAMES,PATH),
           SUBJCT='(
             TRAINJ (THE RELATIVITY OF THE FRAMES OF
               REFERENCE.)
             TRAINK (DIFFERENCES IN THE SITUATION WHEN
               VIEWED FROM THE FRAME OF REFERENCE OF
               THE TRAIN RATHER THAN THE GROUND.)
             TRAIND (MEASUREMENT OF LENGTH.)
             TRAINH (SYNCHRONIZATION OF WATCHES.)
             TRAINI (SIMULTANEITY OF EVENTS.)
             TRAINF (THE CONDITIONS WHICH DETERMINE
               THE EMISSION OF THE LIGHT SIGNALS.)
             TRAING (GRAPHS OF THE EVENTS AS VIEWED
               FROM THE GROUND FRAME OF REFERENCE.)
             TRAINB (GRAPHS OF THE EVENTS AS VIEWED
               FROM THE TRAIN FRAME OF REFERENCE.)
             ),
           HINTS='(HINT1),
           TXTPRT('(TRAIN SCRIPT. A DISCUSSION OF THE TRAIN
             PARADOX OF SPECIAL RELATIVITY.),STOUT),
:VARIABLE RESPONSES OF PLEASE REPHRASE THAT:
           REPEAT='(ARRAY 4 12),
           REPEAT(1,1)='(PLEASE REWORD),
           REPEAT(1,10)='(PLEASE REWORD),
           REPEAT(4,1)='(.), REPEAT(4,10)='(.),
```

```
          REPEAT(1,3)='(), REPEAT(1,12)='(),
          REPEAT(4,3)='(IS A BIT UNCLEAR TO ME. PLEASE REWORD IT.),
          REPEAT(4,12)='(IS A BIT UNCLEAR TO ME. PLEASE REWORD IT.),
          REPEAT(1,5)='(WOULD YOU ELABORATE),
          REPEAT(1,2)='(WOULD YOU ELABORATE),
          REPEAT(4,5)='(PLEASE.), REPEAT(4,2)='(PLEASE.),
          REPEAT(1,7)='(I DON'T QUITE UNDERSTAND),
          REPEAT(1,4)='(I DON'T QUITE UNDERSTAND),
          REPEAT(4,7)='(. PLEASE REPHRASE YOUR STATEMENT.),
          REPEAT(4,4)='(. PLEASE REPHRASE YOUR STATEMENT.),
          REPEAT(1,9)='(PLEASE REPHRASE),
          REPEAT(1,6)='(PLEASE REPHRASE),
          REPEAT(4,9)='(.), REPEAT(4,6)='(.),
          REPEAT(1,11)='(I DON'T COMPLETELY UNDERSTAND),
          REPEAT(1,8)='(I DON'T COMPLETELY UNDERSTAND),
          REPEAT(4,11)='(. PLEASE REWORD IT.),
          REPEAT(4,8)='(. PLEASE REWORD IT.),
          FOR (J=2) (J=J+2) (J .G. 12)
            (REPEAT(2,J)='(WHAT YOU ARE SAYING)) ,
          FOR (J=1) (J=J+2) (J .G. 12)
            (REPEAT(2,J)='(YOUR STATEMENT)) ,
          :PUTTING THE SEGMENTS TOGETHER:
          FOR (J=1) (J=J+1) (J .G. 12)
            ( NEWBOT(REPEAT(2,J),REPEAT(1,J)) ) ,
:DEFINITIONS OF FUNCTIONS:
:TTT-PUTTING PAIRS ON TABLE AND KEEPING COPY:
          DEFINE(TTT(PAIRS)=
            NEWTOP(PAIRS,TABLE),
            ELBAT=PAIRS, ),
:KKK-SEARCHING THE KEYSTACK FOR ANOTHER KEYWORD:
          DEFINE(KKK(ABC)=
            HIRANK(ABC,0,-1),
            Z=HIRANK(ABC,0,1),
            IF(Z .NE. 0) 'NEXT 'A ,
            NEWTOP(ELBAT,TABLE),
            KEY=Z,
            EXP=INPUT.
  *A        NEWTOP('NOKEY,DAHIN), ),
:FFF-DETERMINING FRAME OF REFERENCE MEANT IN ANSWER:
          DEFINE(FFF(LST)=
            LSLCPY(LST,MTLIST(TUPNI)),
  *A        IF(MATCH('(0 (*FRAME REFERENCE) 0),TUPNI,MTLIST(PMOCED))
              .NE. 0) 'C 'NEXT ,
            TXTPRT('(WHICH FRAME OF REFERENCE ARE YOU VIEWING THE
              SITUATION FROM.),STOUT),
  *B        RDLONL(MTLIST(TUPNI)),
            TXTPRT(TUPNI,STOUTN),
  *C        IF(MATCH('(0 (*TRAIN GROUND) 0),TUPNI,MTLIST(PMOCED))
              .NE. 0) 'D 'NEXT ,
            TXTPRT('(PLEASE REFER TO THE FRAME OF REFERENCE AS
              EITHER TRAIN OR GROUND.),STOUT),
            GOTO('B),
  *D        ASSMBL('(2),PMOCED,MTLIST(YLBMES)),
            NEWTOP(TOP(YLBMES),FRAME),
```

```
            TOP(YLBMES) ),
:CCC-PRINTING TOGETHER SEGMENTS OF SENTENCES:
          DEFINE(CCC(LST1,LST2,LST3)=
            NEWBOT(LST2,LST1),
            NEWBOT(LST3,LST1),
            TXTPRT(LST1,STOUT),
            POPBOT(LST1),
            POPBOT(LST1), ),
:GET TRAINL SCRIPT TO CALL IN TRAINE SCRIPT:
          SCRIPT(SB,'TRAINL), GROUP='2 , NEWTOP('BEGIN,DAHIN).
          END)
```

TRAINA SCRIPT

```
(WAIT      (200000 WAIT (
           (0) () WAIT )))
(BBBBB     (222222 BBBBB (
            (1 0) (2) OPL )))
(SCRIPT    (80000 SCRPT        (
           (2 SCRIPT) () SCRPT ) AGAIN ))
(AREN'T=ARE NOT)
(WON'T=WILL NOT)
(DON'T=DO NOT)
(DIFFERENT          (45 DIFF  (
           (0 (*D F) AND (*D F) 0 NOT 0 (*SEE OBSERVE) 0 DIFFERENT
             (*TIMES TIME) 0) (WRONG) NP
           (0 (*D F) AND (*D F) 0 (*SEE OBSERVE) 0 DIFFERENT
             (*TIMES TIME) 0) () RIGHT
           (0 NOT (*EMITTED SENT FLASHED) 0 DIFFERENT (*TIMES TIME))
             (WRONG) NP
           (0 (*EMITTED SENT FLASHED) 0 DIFFERENT (*TIMES TIME)) ()
             SIM1
           (0 DIFFERENT (*TIME TIMES) 0 DLIST(DIFFQ1)) () AGAIN)
           AGAIN))
(C         (35 FROMC (
           (0 DLIST(FROMCQ)) () AGAIN)))
(F         (34 FROMF (
           (0 DLIST(FROMFQ)) () AGAIN)))
(NO        (9 NO     (
           (0 DLIST(NOQ)) () AGAIN)))
(YES       (8 YES    (
           (0 DLIST(YESQ)) () AGAIN)))
(SAME TIME = SIMULTANEOUSLY.)
(SIMULTANEOUSLY  (50 SIM      (
           (0 (*D F) AND (*D F) 0 NOT (*SEE OBSERVE) 0
             SIMULTANEOUSLY 0) () RIGHT
           (0 NOT (*EMITTED SENT FLASHED) 0 SIMULTANEOUSLY) () SIM1
           (0 DLIST(SIMQ1)) (ABOUT WHAT OCCURS SIMULTANEOUSLY) ()
             UNDER)))
(NOT       (NOT      (
           (0) () NOKEY)))
(PROG      (TRAINA
           TXTPRT(INPUT,STOUTN),
           SVLBL=LABEL,
           LABEL=POPTOP(DAHIN),
           GOTO(LABEL).
*START     IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
           COUNTA=0 ,
:RECORDING OF INFORMATION ABOUT THE STUDENT:
           TXTPRT('(PLEASE TYPE YOUR NAME, YOUR YEAR,
             YOUR COURSE, AND WHETHER YOU HAVE TAKEN,
             HAVE NOT TAKEN, OR ARE TAKING 8.02.),STOUT),
           TTT('(O'E AA)).
*AA        L1='(OBSERVERS D, E, AND F ARE RIDING IN A TRAIN WHICH IS
             TRAVELLING TO THE RIGHT WITH A CONSTANT
             RELATIVISTIC VELOCITY V WITH RESPECT TO
```

```
            THE FRAME OF REFERENCE OF OBSERVERS A, B, AND C, WHO ARE
            AT REST WITH RESPECT TO THE GROUND.  CONSIDER BOTH
            FRAMES AS INERTIAL FRAMES OF REFERENCE.
            B IS HALFWAY BETWEEN
            A AND C, AND E IS HALFWAY BETWEEN D AND F.
            WHEN D PASSES A, A FLASHES A SINGLE LIGHT
            SIGNAL TOWARD B. WHEN F PASSES C, C FLASHES A
            SINGLE LIGHT SIGNAL TOWARD B. ASSUME THAT
            THE DISTANCE BETWEEN A AND C IS SUCH THAT ACCORDING TO
            THE SYNCHRONIZED WATCHES OF A AND C,
            D PASSES A AT THE SAME TIME
            THAT F PASSES C.),
          TXTPRT(L1,STOUT), IRALST(L1),
          TXTPRT(XECOM('(PRINT GRAPH ONE)),STOUTN),
*AB       TXTPRT('(WILL B SEE THE SIGNALS SIMULTANEOUSLY OR AT
            DIFFERENT TIMES.),STOUT),
          TTT('(SIMQ1 AC DIFFQ1 AD O'E AB1)).
*AB1      TXTPRT('(PLEASE ANSWER EITHER SIMULTANEOUSLY
            OR AT DIFFERENT TIMES.),STOUT),
          NEWTOP(ELBAT,TABLE).
*AC       TXTPRT('(CORRECT.  NOW IF E IS ALSO ABLE TO SEE THE LIGHT
            SIGNALS, WILL HE OBSERVE THEM SIMULTANEOUSLY OR AT
            DIFFERENT TIMES.),STOUT),
          TTT('(SIMQ1 AE DIFFQ1 AF O'E AB1)).
*AD       TXTPRT('(WRONG),STOUT),
          GOTO('AB),
*AE       NEWBOT('(-1),ESEE),
          PLACE='BEGIN, SCRNAM='TRAING, GOTO('CHANGE).
*AF       TXTPRT('(WHICH SIGNAL WILL E SEE FIRST.),STOUT),
          NEWBOT('(1),ESEE),
          TTT('(FROMCQ AG FROMFQ AH O'E AF)).
*AG       TXTPRT('(YOU'RE RIGHT. BUT LET'S EXAMINE ANOTHER
            POSSIBLE ANSWER. ONE STUDENT SAYS-),STOUT),
          TXTPRT('(IN THE FRAME OF REFERENCE OF THE TRAIN,
            THE TRAIN APPEARS TO BE AT REST AND THE GROUND
            APPEARS TO BE MOVING WITH A VELOCITY V TO THE
            LEFT.  D AND F SEE THE LIGHT SIGNALS EMITTED AT
            THE SAME TIME ACCORDING TO THEIR SYNCHRONIZED
            WATCHES.  THE SPEED OF LIGHT IS INDEPENDENT OF
            THE SOURCE VELOCITY AND EQUAL TO THE CONSTANT C
            IN ALL INERTIAL FRAMES OF REFERENCE, AND THE
            DISTANCES DE AND EF ARE EQUAL.  THEREFORE, E
            WILL SEE THE SIGNAL FROM A BEFORE THE SIGNAL
            FROM C, SINCE B WILL BE TRAVELLING TOWARD THAT
            SIGNAL.),STOUT),
          TXTPRT('(THIS OBVIOUSLY CONTRADICTS YOUR
            ANSWER. WHAT IS WRONG WITH THIS
            ANALYSIS.),STOUT),
          COUNTA=1 ,
          ELBAT='() .
*AH       TXTPRT('(DO YOU MEAN THE SIGNAL WHICH C FLASHES.),STOUT),
          TTT('(YESQ AG NOQ AF O'E YSORNO)).
*SIM1     FFF(INPUT),
          TIME=1 ,
```

```
        L9='(IN THE FRAME OF REFERENCE OF THE ),
        NEWBOT(FRAME,L9),
        IF((TOP(FRAME) .E. 'TRAIN) .AND. (TIME .NE. 0))
          'RIGHT 'NEXT ,
        TXTPRT(L9,STOUT), GOTO('NP).
*RIGHT  L10='(IN THE FRAME OF REFERENCE OF THE TRAIN,),
        TIME=1 ,
        CCC('(CORRECT.),L10,'(THE SIGNALS ARE
          NOT EMITTED AT THE SAME TIME.)),
        TRSEND=1 , GOTO('FINISH).
*CHOOSE GROUP='1 , NEWTOP('CHOOSE,DAHIN).
*SCRPT  PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH :REACHED END OF THIS LEVEL OF DISCUSSION-
         CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
        IF(LEMPTY(STORE))
          :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
          'WHERE
          :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
          ( SUBSCR=1 ) ,
        GOTO('CHANGE).
*WHERE  GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB TXTPRT(SEMBLY,STOUT).
*YSORNO TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
        NEWTOP(ELBAT,TABLE).
*AGAIN  KKK(KEESTK).
*NP     TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL    EVAL(SEMBLY).
*WAIT   GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY  IF(COUNTA .L. 4)
          ( COUNTA=COUNTA+1 )
          ( GOTO('FINISH) ),
        NKFLAG=1 ,
*UNDER  GROUP='1 , NEWTOP('UNDER,DAHIN).
        END)
```

TRAINB SCRIPT

```
(BBBBB     (222222 BBBBB       (
           (1 0) (2) OPL )))
(WAIT      (200000 WAIT        (
           (0) () WAIT )))
(SCRIPT    (80000 SCRPT        (
           (2 SCRIPT) () SCRPT ) AGAIN ))
(DON'T=DO  NOT)
(KNOW      (500 KNOW (
           (0 I DO NOT KNOW 0 DLIST(KNOWQ1)) () AGAIN)
           AGAIN))
(ED=DE)
(FE=DE)
(EF=DE)
(FD=DF)
(BA=AB)
(CB=AB)
(BC=AB)
(CA=AC)
(EQUALS= THE SAME.)
(EQUAL = THE SAME.)
(SIMULTANEOUS       (100 SM    (
           (0 SEPARATED SIMULTANEOUS 0 SIMULTANEOUS 0
             (*FRAME MOVING) 0 (*FRAME MOVING) 0) (SM1 SM2 RELATIVE
             SIMULTANEITY) NOT
           (0) (ABOUT SIMULTANEOUS EVENTS) UNDER )))
(THE SAME (75 TSM    (
           (0 (*AC DF) 0 (*AC DF) 0) () TSM1
           (0 (*AB DE) 0 (*AB DE) 0) () TSM1)
           AGAIN))
(CONTINUE (50 CON (
           (0) () CON1 )))
(STOP      (50 STOP (
           (0) () STOP1 )))
(LORENTZ CONTRACTION          (90 LC     (
           (0 (* GROUND ABC) 0 (*CONTRACTED SHORTER SHORTENED) 0)
             (THE LORENTZ CONTRACTION) LC1
           (0 (*TRAIN DEF) 0 (*LENGTHENED LONGER) 0)
             (THE LORENTZ CONTRACTION) LC1
           (0 DLIST(LCQ)) (ABOUT THE LORENTZ CONTRACTION) UNDER )))
(YES       (8 YES     (
           (0 DLIST(YESQ)) (1 WHAT) PRSEMB)))
(NO        (9 NO      (
           (0 DLIST(NOQ)) (1 WHAT) PRSEMB)))
(NOT       (NOT       (
           (0) () NOKEY)))
(PROG      (TRAINB
           TXTPRT(INPUT,STOUTN),
           SVLBL=LABEL,
           LABEL=POPTOP(DAHIN),
           GOTO(LABEL).
*START     IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
           TXTPRT('(WHY DO THE LIGHT SIGNALS APPEAR TO BE EMITTED AT
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          DIFFERENT TIMES IN THE FRAME OF REFERENCE OF THE
          TRAIN.),STOUT),
        TTT('(KNOWQ1 BD)).
*NOT    NNNNA=POPTOP(SEMBLY), NNNNB=POPTOP(SEMBLY),
        IF(WASKEY('NOT,KEESTK) .E. 0) NNNNA NNNNB .
*BA     TXTPRT('(WOULD YOU LIKE TO SEE GRAPHS OF THE SITUATION AS
          SEEN FROM THE FRAME OF REFERENCE OF THE TRAIN.),STOUT),
        TTT('(YESQ CON1 NOQ BC)).
*BB     TXTPRT('(WHAT IS THE EFFECT OF THE LORENTZ CONTRACTION
          THAT YOU ARE THINKING ABOUT THEN.),STOUT),
        GOTO('NP).
*BC     TXTPRT('(WHAT IS THE EFFECT OF RELATIVE SIMULTANEITY YOU
          ARE THINKING ABOUT THEN.),STOUT),
        GOTO('NP).
*BD     TXTPRT('(LET ME ASK YOU A FEW QUESTIONS TO HELP
          GUIDE YOUR THINKING.),STOUT),
        NEWTOP('(BA TRAINB),STORE),
        PLACE='BEGIN, SCRNAM='TRAIND,
        GOTO('CHANGE).
*GRAPHS TXTPRT('(CONSIDER THE FOLLOWING DIAGRAM),STOUT),
*CON1   IF(LEMPTY(NUMBER)) 'CON1A 'NEXT ,
        N=POPTOP(NUMBER),
        SUBSBT(N,GRPRNT),
        TXTPRT(XECOM(GRPRNT),STOUTN),
        TXTPRT('(SHALL I CONTINUE WITH THE NEXT
          GRAPH.),STOUT),
        TTT('(YESQ CON1 NOQ WAIT O'E YSORNO)).
*CON1A  TXTPRT('(THESE ARE ALL THE GRAPHS.  DO YOU UNDERSTAND
          NOW WHY THE LIGHT SIGNALS APPEAR TO BE EMITTED AT
          DIFFERENT TIMES IN THE FRAME OF REFERENCE OF THE
          TRAIN.),STOUT),
        TTT('(YESQ BE NOQ FINISH O'E YSORNO)).
*BE     TXTPRT('(VERY GOOD. WE HAVE ACCOMPLISHED THE
          PURPOSE OF THIS CONVERSATION.),STOUT),
        GROUP='1 , NEWTOP('FINAL,DAHIN).
*STOP1  NEWTOP('(CON1 TRAINB),STORE),
        PLACE='BEGIN, SCRNAM='TRAINC,
        GOTO('CHANGE).
*SM1    :SIMULTANEITY SAME IN DIFFERENT FRAMES:
        GOTO('NP).
*SM2    TTT('(YESQ BA NOQ BC)),
        NEWTOP('1,SM),
        GOTO('GRAPHS).
*TSM1   TT=(FFF(INPUT) .E. 'TRAIN),
        TN=(MATCH('(0 NOT THE SAME 0),INPUT,MTLIST(PMOCED))
          .NE. 0),
        IF(TT .AND. TN) 'TSM1A 'NEXT,
        IF(TT .AND. .NOT. TN) 'TSM1B 'NEXT,
        TXTPRT('(TRIVIAL CASES),STOUT),
        GOTO('NP),
*TSM1A  TXTPRT('(WHY DO THE DISTANCES APPEAR TO BE UNEQUAL IN
          LENGTH),STOUT),
        TTT('(LCQ LC1)).
*TSM1B  GOTO('NP).
```

```
*SCRPT     PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE    GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH    :REACHED END OF THIS LEVEL OF DISCUSSION-
            CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
           IF(LEMPTY(STORE))
             :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
             'WHERE
             :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
             ( SUBSCR=1 ) ,
           GOTO('CHANGE).
*WHERE     GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB    TXTPRT(SEMBLY,STOUT).
*YSORNO    TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
           NEWTOP(ELBAT,TABLE).
*AGAIN     KKK(KEESTK).
*NP        TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL       EVAL(SEMBLY).
*WAIT      GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY     NKFLAG=1,
*UNDER     GROUP='1 , NEWTOP('UNDER,DAHIN).
           END)
```

TRAINC SCRIPT

```
(BBBBB    (222222 BBBBB (
          (1 0) (2) OPL)))
(WAIT     (200000  WAIT (
          (0) () WAIT )))
(SCRIPT   (80000 SCRPT        (
          (2 SCRIPT) () SCRPT ) AGAIN ))
(LONGER   (100 LONG (
          (0 (*TRAIN DEF DF) 0 LONGER THAN 0 (*GROUND ABC AC) 0) ()
            LONG1)
          (0) (ABOUT WHAT IS LONGER) UNDER )))
(SHORTER  (101 SHORT          (
          (0 (* GROUND ABC AC) 0 SHORTER THAN 0 (*TRAIN DEF DF) 0) ()
            SHOR1)
          (0) (ABOUT WHAT IS SHORTER) UNDER )))
(LIGHT SIGNAL        (80 LS    (
          (0 LIGHT SIGNAL FROM A 0 (*EMITTED SENT FLASHED) 0) () LS1
          (0 FROM A 0) () LS1)
          (0) (ABOUT THE LIGHT SIGNAL) UNDER )))
(GROUND   (75 GRND  (
          (0 (*MOVE MOVES MOVING) 0) () GRND1)
          (0) (ABOUT THE GROUND) UNDER )))
(SAME TIME=SIMULTANEOUSLY.)
(SIMULTANEOUSLY      (60 ST    (
          (0 B SEE 0 SIMULTANEOUSLY 0) () ST1)
          (0) (ABOUT WHAT OCCURS SIMULTANEOUSLY) UNDER )))
(CONTINUE (50000 CONT         (
          (0) () CONT1 )))
(NO       (9 NO      (
          (0 DLIST(NOQ)) () AGAIN)))
(YES      (8 YES     (
          (0 DLIST(YESQ)) () AGAIN)))
(NOT      (NOT       (
          (0) () NOKEY)))
(PROG     (TRAINC
          TXTPRT(INPUT,STOUTN),
          LABEL=POPTOP(DAHIN),
          GOTO(LABEL).
*START    ELBAT='(),
          IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
          L1='(WHAT DON'T YOU UNDERSTAND ABOUT GRAPH),
          NEWBOT(N,L1),
          TXTPRT(L1,STOUT).
*LONG1    TXTPRT('(THE LENGTH DEF APPEARS TO BE LONGER THAN THE
            LENGTH ABC BECAUSE OF THE LORENTZ CONTRACTION.  DO
            YOU UNDERSTAND THE LORENTZ CONTRACTION.),STOUT),
          GOTO('NP),
*LS1      TXTPRT('(THE LIGHT SIGNAL FROM A IS SENT WHEN A PASSES D.
            YOU WILL SEE THIS ON GRAPH SIX.),STOUT).
*GRND1    TXTPRT('(THE GROUND FRAME APPEARS TO BE MOVING
            WHEN VIEWED FROM THE TRAIN FRAME BECAUSE THEY
            ARE BOTH INERTIAL FRAMES, AND MOTION IS
            A RELATIVE CONCEPT FOR INERTIAL FRAMES OF
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              REFERENCE.),STOUT).
*ST1        TXTPRT('(AS VIEWED FROM THE FRAME OF REFERENCE OF
              THE GROUND, B SEES THE LIGHT SIGNALS SIMULTANEOUSLY.
              THIS CAN BE THOUGHT OF AS A SINGLE EVENT-
              THE EXISTENCE OF THE TWO LIGHT SIGNALS AND B
              AT A SINGLE POINT IN SPACE AND TIME. IN THE
              TRAIN FRAME, THIS WILL STILL BE A SINGLE
              EVENT.),STOUT).
*CONT1      GROUP='1 , KEESTK=KA, NEWTOP('GOBACK,DAHIN).
*SCRPT      PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE     GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH     :REACHED END OF THIS LEVEL OF DISCUSSION-
             CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
            IF(LEMPTY(STORE))
              :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
              'WHERE
              :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
              ( SUBSCR=1 ) ,
            GOTO('CHANGE).
*WHERE      GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB     TXTPRT(SEMBLY,STOUT).
*YSORNO     TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
            NEWTOP(ELBAT,TABLE).
*AGAIN      KKK(KEESTK).
*NP         TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL        EVAL(SEMBLY).
*WAIT       GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY      NKFLAG=1,
*UNDER      GROUP='1 , NEWTOP('UNDER,DAHIN).
            END)
```

TRAIND SCRIPT

```
(BBBBB      (222222 BBBBB        (
            (1 0) (2) OPL )))
(WAIT       (200000 WAIT         (
            (0) () WAIT )))
(SCRIPT     (80000 SCRPT         (
            (2 SCRIPT) () SCRPT ) AGAIN ))
(GRAPH=GRAPHS.)
(GRAPHS     (72 GRPH  (
            (0 BY GRAPHS 0 DLIST(GRPHQ)) () AGAIN )))
(EQUATION=EQUATIONS.)
(EQUATIONS            (70 EQN   (
            (0 BY EQUATIONS 0 DLIST(EQNQ)) () AGAIN )))
(DISCUSSION           (71 DISS  (
            (0 BY DISCUSSION 0 DLIST(DISSQ)) () AGAIN )))
(TRAIN      (51 TRN    (
            (0 GROUND 0 DLIST(TRNQ1)) () AGAIN
            (0 DLIST(TRNQ2)) (ABOUT THE TRAIN) UNDER )))
(GROUND     (50 GRN    (
            (0 DLIST(GRNQ)) (ABOUT THE GROUND) UNDER )))
(YES        (8 YES     (
            (0 DLIST(YESQ)) () AGAIN )))
(NO         (9 NO      (
            (0 DLIST(NOQ)) () AGAIN )))
(NOT        (NOT       (
            (0) () NOKEY )))
(PROG       (TRAIND
            TXTPRT(INPUT,STOUTN),
            SVLBL=LABEL,
            LABEL=POPTOP(DAHIN),
            GOTO(LABEL).
*START      IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
            LIST(GED),
            TXTPRT('(IN GRAPH ONE, THE DISTANCE AC APPEARS TO BE
              EQUAL TO THE DISTANCE DF. IN WHICH FRAME OR FRAMES OF
              REFERENCE IS THIS TRUE.),STOUT),
            TTT('(TRNQ1 DA TRNQ2 DA GRNQ DB O'E DC)),
            TRUGRN='(IT IS TRUE IN THE GROUND FRAME OF REFERENCE),
            FALTRN='(THE LENGTHS ARE NOT EQUAL IN THE TRAIN FRAME
              OF REFERENCE.).
*DA         TXTPRT('(DO YOU UNDERSTAND THE LORENTZ
              CONTRACTION),STOUT),
            TTT('(YESQ DF NOQ DF O'E YSORNO)).
*DB         CCC(TRUGRN,'(.),'(IS IT ALSO TRUE IN THE FRAME OF
              REFERENCE OF THE TRAIN.)),
            TTT('(YESQ DD NOQ DE)).
*DC         TXTPRT('(PLEASE REFER TO THE FRAMES OF REFERENCE AS
              'TRAIN FRAME' AND 'GROUND FRAME'.  IN WHICH FRAME
              OR FRAMES OF REFERENCE IS AC = DF.),STOUT),
            NEWTOP(ELBAT,TABLE).
*DD         CCC('(WRONG.),'(),FALTRN),
            GOTO('LORENT).
*DE         CCC('(CORRECT.),'(),FALTRN),
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         GOTO('LORENT).
*LORENT  TXTPRT('(THE LORENTZ CONTRACTION IS THE NAME
           GIVEN TO THIS APPARENT CONTRACTION OF LENGTH
           IN A MOVING FRAME OF REFERENCE.  DO YOU
           UNDERSTAND THIS CONCEPT.),STOUT),
         TTT('(YESQ DF NOQ DG)).
*DF      TXTPRT('(DO YOU SEE WHY THE LORENTZ CONTRACTION WILL
           MAKE THE DISTANCES APPEAR TO BE UNEQUAL WHEN
           MEASURED IN THE TRAIN FRAME.),STOUT),
         TTT('(YESQ DH NOQ DI)).
*DG      TXTPRT('(I SUGGEST YOU READ THE SECTION IN THE TEXT
           ON THE LORENTZ CONTRACTION.  IN THE MEANTIME,
           YOU MAY CONTINUE.),STOUT),
         GOTO('DK).
*DH      GOTO('DK).
*DI      TXTPRT('(WOULD YOU LIKE TO HAVE THIS EXPLAINED BY GRAPHS,
           BY EQUATIONS, OR BY DISCUSSION.),STOUT),
         TTT('(O'E DJ)),
         LBL='NOKEY,
         MAKEDL('(DJ1G (GRAPHS) DJ1D (DISCUSSION) DJ1E (EQUATIONS)),
           MTLIST(GED)).
*DJ      IF(WASKEY('GRPH,KEESTK) .E. 0) 'NEXT (NEWBOT('DJ1G,GED)) ,
         IF(WASKEY('DISS,KEESTK) .E. 0) 'NEXT (NEWBOT('DJ1D,GED)) ,
         IF(WASKEY('EQN,KEESTK) .E. 0) 'NEXT (NEWBOT('DJ1E,GED)) ,
*DJ1     IF(LEMPTY(GED)) (GOTO(LBL)) 'NEXT ,
         IF(LBL .E. 'NOKEY) (GOTO(POPTOP(GED))) 'NEXT ,
         LBL=POPTOP(GED),
         L1='(YOU ALSO MENTIONED A PREFERENCE FOR),
         NEWBOT(ITSVAL(LBL,GED),L1),
         L2='(WOULD YOU LIKE TO HAVE THE LORENTZ CONTRACTION
           EXPLAINED IN THIS WAY TOO.),
         CCC(L1,'(.),L2),
         POPBOT(L1),
         L3='(NOQ DJ1 O'E YSORNO),
         NEWTOP(LBL,L3), NEWTOP('YESQ,L3),
         TTT(L3).
*DJ1G    TXTPRT(XECOM('(PRINT GRAPH NINE)),STOUTN),
         LBL='DK,
         GOTO('DJ1).
*DJ1D    TXTPRT('(THIS WILL BE PROGRAMMED FOR DISCUSSION LATER.
           TRY GRAPHS.),STOUT),
         :PUT IN GOTO DI TEMPORARILY AFTER TEST:
         LBL='DK,
         GOTO('DJ1).
*DJ1E    TXTPRT(XECOM('(PRINT EQN ONE)),STOUTN),
         LBL='DK,
         GOTO('DJ1).
*DK      PLACE='BA, SCRNAM='TRAINB, GOTO('CHANGE).
*SCRPT   PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE  GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH  :REACHED END OF THIS LEVEL OF DISCUSSION-
          CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
         IF(LEMPTY(STORE))
           :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
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             'WHERE
             :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
             ( SUBSCR=1 ) ,
           GOTO('CHANGE).
*WHERE     GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB    TXTPRT(SEMBLY,STOUT).
*YSORNO    TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
           NEWTOP(ELBAT,TABLE).
*AGAIN     KKK(KEESTK).
*NP        TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL       EVAL(SEMBLY).
*WAIT      GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY     NKFLAG=1,
*UNDER     GROUP='1 , NEWTOP('UNDER,DAHIN).
           END)
```

TRAINE SCRIPT

```
(GO BACK = CONTINUE.)
(CONTINUE (60000 CONT          (
          (0 DLIST(CONTQ)) () GOBACK )))
(QUESTION (70000 QUEST         (
          (0) () QUEST )))
(QUIT     (100000 QUIT         (
          (0) () QUIT )))
(RELATIVITY         (8880 REL (
          (0) (BEGIN TRAINJ) AGAIN )))
(DIFFERENCES = DIFFERENCE.)
(DIFFERENCE         (8870 DIFF (
          (0) (BEGIN TRAINK) AGAIN )))
(MEASUREMENT        (8860 MEAS (
          (0) (BEGIN TRAIND) AGAIN )))
(SYNCHRONIZATION    (8850 SYNC          (
          (0) (BEGIN TRAINH) AGAIN )))
(SIMULTANEITY       (8840 SIM (
          (0) (BEGIN TRAINI) AGAIN )))
(EMISSION (8830 EMIS           (
          (0) (BEGIN TRAINF) AGAIN )))
(GRAPHS = GRAPH.)
(GRAPH    (8820 GRPH           (
          (0 GROUND 0) (GB TRAING) AGAIN
          (0 TRAIN 0) (BA TRAINB) AGAIN )
          AGAIN))
(CHANGE   (10003 CHNG (
          (0 CHANGE 0 APPROACH 0 TO 0
            (*DETERMINE LEAD HINT) 0) (8) DIRECT
          (0 CHANGE 0 APPROACH 0) () DIRECT )
          AGAIN))
(DETERMINE          (9993 DET (
          (0) (FREE) AGAIN )))
(LEAD     (9992 LEAD           (
          (0) (LEAD) AGAIN )))
(HINTS=HINT.)
(HINT     (9991 HINT           (
          (0) (HINT) AGAIN )))
(BBBBB    (222222 BBBBB        (
          (1 0) (2) OPL )))
(WAIT     (200000 WAIT         (
          (0) () WAIT )))
(SCRIPT   (80000 SCRPT         (
          (2 SCRIPT) () SCRPT ) AGAIN ))
(NO       (9 NO     (
          (0 DLIST(NOQ)) () AGAIN)))
(YES      (8 YES    (
          (0 DLIST(YESQ)) () AGAIN)))
(PROG     (TRAINE
          TXTPRT(INPUT,STOUTN),
          GOTO(POPTOP(DAHIN)).
*START    IF(PLACE .E. 'BEGIN) 'FIRST PLACE ,
*CHOOSE   TXTPRT('(IN OUR DISCUSSION, YOU HAVE A CHOICE
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              OF THE TYPE OF APPROACH TO THE PROBLEM WHICH
              WE WILL FOLLOW.),STOUT),
            TXTPRT('(YOU MAY DETERMINE THE TOPICS OF
              DISCUSSION YOURSELF FROM A LIST OF TOPICS
              I WILL GIVE YOU, OR YOU MAY LET ME LEAD
              THE DISCUSSION, OR YOU MAY TRY TO SOLVE
              THE PROBLEM WITH THE AID OF SOME HELPFUL
              HINTS FROM ME.  AT ANY TIME, YOU MAY CHANGE
              THIS CHOICE BY INTERRUPTING THE CONVERSATION
              AND TELLING ME YOU WANT TO CHANGE YOUR
              APPROACH. WHAT IS YOUR INITIAL
              CHOICE.),STOUT),
            TTT('(O'E CHOOS1)).
*DIRECT     TTT('(O'E CHOOS1)),
            IF(LEMPTY(SEMBLY))
              ( TXTPRT('(WHICH APPROACH DO YOU WANT TO
                 CHANGE TO.),STOUT) )
              ( KKK(KA) ) .
*CHOOS1     CHOICE=TOP(SEMBLY),
*CHOOS2     IF(CHOICE .E. 'LEAD) 'MAP 'NEXT ,
            IF(CHOICE .E. 'FREE) 'WHICH 'NEXT ,
            IF(CHOICE .E. 'HINT) 'HINT 'NEXT ,
            TXTPRT('(I DON'T RECOGNIZE YOUR CHOICE OF
              APPROACH. PLEASE REPHRASE YOUR
              STATEMENT.),STOUT),
            TTT('(O'E CHOOS1)).
:THE CHOICE IS FOR A LED DISCUSSION:
*MAP        MTLIST(PATH),
            IF(TRSEND .NE. 1)
              ( NEWTOP('TRAINI,PATH) )
              'NEXT ,
            IF(LENGTH .NE. 1)
              ( NEWTOP('TRAIND,PATH),
                NEWTOP('TRAINF,PATH), )
              'NEXT ,
            IF(RLATIV .NE. 1)
              ( NEWTOP('TRAINJ,PATH) )
              'NEXT ,
:LED DISCUSSION, FOLLOW THE PATH:
*FOLLOW     IF(LEMPTY(PATH))
              ( SEMBLY='(),
                TXTPRT('(THIS IS AS FAR AS I CAN
                 LEAD YOU.),STOUT),
                GOTO('DIRECT). )
              'NEXT ,
            TXTPRT('(LET'S DISCUSS THE FOLLOWING.),STOUT),
            PLACE='BEGIN,
            SCRNAM=POPTOP(PATH),
            GOTO('CHANGE).
:FREEDOM OF DISCUSSION, STUDENT'S CHOICE:
*WHICH      TXTPRT('(WE CAN DISCUSS ANY OF THE
              FOLLOWING TOPICS.),STOUT),
            RDR=SEQRDR(SUBJCT),
:PRINTING OF THE SUBJECTS FOR DISCUSSION:
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*WHICH1   IF(X .E. 'NIL) 'WHICH2 'NEXT ,
          X=SEQLR(RDR),
          IF(X .E. 'NIL) 'WHICH2 'NEXT ,
          X=SEQLR(RDR),
          TXTPRT(X,STOUT),
          GOTO('WHICH1).
*WHICH2   TXTPRT('(WHICH OF THE SUBJECTS WOULD YOU LIKE
            TO DISCUSS.),STOUT),
          TTT('(O'E WHICH3)).
*WHICH3   SCRNAM=BOT(SEMBLY),
          PLACE=TOP(SEMBLY),
          GOTO('CHANGE).
:THE CHOICE IS TO PROCEED WITH HINTS:
*HINT     IF(LEMPTY(HINTS))
            'NEXT
            ( TXTPRT('(LET'S CONSIDER
               THE FOLLOWING.),STOUT),
              GOTO(POPTOP(HINTS)). ) ,
          TXTPRT('(I HAVE GIVEN YOU ALL THE HELPFUL
            HINTS I HAVE. WOULD YOU LIKE TO DETERMINE
            THE COURSE OF CONVERSATION YOURSELF, OR
            HAVE THE DISCUSSION LED BY ME.),STOUT),
          TTT('(O'E CHOOS1)).
*HINT1    PLACE='BEGIN, SCRNAM='TRAINH,
          GOTO('CHANGE).
:THIS DIRECTS THE CONVERSATION WHEN
 ALL SUBSCRIPTS HAVE BEEN FINISHED:
*WHERE    TXTPRT('(WE HAVE REACHED THE END OF THIS LINE
            OF THOUGHT.),STOUT),
          IF(TRSEND .E. 1) 'FINAL 'NEXT ,
*WHERE1   IF(CHOICE .E. 'LEAD) 'FOLLOW 'NEXT ,
          IF(CHOICE .E. 'FREE) 'WHICH2 'NEXT ,
          IF(CHOICE .E. 'HINT) 'HINT 'NEXT ,
          IF(CHOICE .E. 0) 'CHOOSE 'CHOOS2 ,
:THE FIRST TIME THROUGH, TRAINA IS THE NEXT SCRIPT:
*FIRST    PLACE='BEGIN,
          LABEL='START,
          SCRNAM='TRAINA,
:THIS IS THE MECHANISM WHICH READS ALL NEW SCRIPTS
 INTO GROUP TWO AND TRANSFERS CONTROL TO THE SCRIPT:
*CHANGE   IF(SUBSCR .E. 1)
            :TRUE-COMING FROM A SUB SCRIPT:
            ( TSTORE=POPTOP(STORE),
              PLACE=TOP(TSTORE),
              SCRNAM=BOT(TSTORE),
              SUBSCR=0 ,
              GOTO('CHANG2) )
            :FALSE-READ NEXT SCRIPT IN NORMALLY:
            'NEXT ,
          :CHECKING TO SEE IF SCRIPT HAS BEEN PLAYED:
          PLAYED=ITSVAL(SCRNAM,PATH),
          IF(PLAYED .E. 'ABSENT) 'CHANG2 'NEXT ,
          IF(PLAYED .E. 1) 'NEXT 'CHANG2 ,
          CCC('(WE HAVE ALREADY DISCUSSED),
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              VALUE(SCRNAM,SUBJCT),
              '(DO YOU WANT TO DISCUSS THIS AGAIN.)),
            TTT('(YESQ CHANG2 NOQ CHANG1 O'E YSORNO)).
*CHANG1     GROUP='2 , NEWTOP('FINISH,DAHIN).
            :RECORDING OF CHANGING SCRIPTS:
*CHANG2     IF(PLACE .E. 'START) ( PLACE='BEGIN ) 'NEXT ,
            NEWTOP(PLACE,DAHIN),
            NEWTOP(SCRNAM,DAHIN),
            TXTPRT(DAHIN,STOUTN),
            POPTOP(DAHIN),
            :INDICATING NEW SCRIPT WILL HAVE BEEN PLAYED:
            NEWVAL(SCRNAM,1,PATH),
            :CHANGING TO NEW SCRIPT:
            LABEL=POPTOP(DAHIN),
            NEWTOP('BEGIN,DAHIN),
            :SEE IF SCRIPT DESIRED IS ALREADY THERE:
            IF(SCRNAM .E. SCRPN2)
              'NEXT
              ( SCRIPT(SB,SCRNAM) ) ,
            GROUP='2 , KEESTK=KB.
:INTERRUPTING COURSE OF DISCUSSION:
*WAIT       POPTOP(INPUT),
            :FIND OUT WHAT STUDENT WANTS TO DO:
            OLDNAM=SCRNAM,
            OLDLBL=SVLBL,
            KA='(),
            KEY=KEY(INPUT,SA,KA),
            IF(KEY .E. 0) 'WAIT1 'NEXT ,
            EXP=INPUT.
*WAIT1      TXTPRT('(WHAT DO YOU WANT TO DO.),STOUT),
            TTT('(O'E WAIT1)).
*QUIT       TXTPRT('(THANK YOU FOR YOUR ATTENTION.  I HOPE
              THAT I HAVE BEEN ABLE TO HELP YOU.),STOUT),
            TXTPRT(NAMES,STOUTN),
            QUIT(0).
*QUEST      IF(SCRNAM .E. 'TRAINB) 'QUESTB 'NOANS ,
*QUESTB     PLACE='BEGIN, SCRNAM='TRAINC,
            GOTO('CHANGE).
*NOANS      TXTPRT('(I AM SORRY BUT I AM NOT PREPARED
              TO ANSWER QUESTIONS ABOUT THIS SUBJECT
              YET. WOULD YOU LIKE TO GO BACK TO WHERE
              WE WERE.),STOUT),
            TTT('(YESQ GOBACK NOQ WAIT1 O'E YSORNO)).
*GOBACK     TXTPRT('(AS I WAS SAYING,),STOUT),
            PLACE=OLDLBL,
            SCRNAM=OLDNAM,
            GOTO('CHANG2).
*FINAL      IF(FNL .E. 0) ( FNL=1 ) 'WHERE1 ,
            TXTPRT('(YOU SEEM TO UNDERSTAND THE
              BASIC IDEA WHICH THIS DISCUSSION HAS
              BEEN AIMED AT, NAMELY, THAT SEPARATED
              EVENTS WHICH ARE VIEWED TO OCCUR AT
              THE SAME TIME IN ONE FRAME OF REFERENCE
              WILL NOT BE VIEWED TO OCCUR SIMULTANEOUSLY
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             IN A FRAME MOVING RELATIVE TO THE FIRST.
             WOULD YOU LIKE TO CONTINUE THE DISCUSSION
             OR WOULD YOU LIKE TO QUIT.),STOUT),
*FINAL1    IF(CHOICE .E. 0)
             ( TTT('(CONTQ CHOOSE O'E NOKEY)) )
             ( TTT('(CONTQ WHERE1 O'E NOKEY)) ) .
*SCRPT     PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
           GOTO('CHANGE).
*PRSEMB    TXTPRT(SEMBLY,STOUT).
*YSORNO    TXTPRT('(PLEASE ANSWER EITHER
             YES OR NO.),STOUT),
           NEWTOP(ELBAT,TABLE).
*AGAIN     KKK(KEESTK).
*NP        TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL       EVAL(SEMBLY).
:THIS IS THE NOKEY AND UNDER RESPONSE MECHANISM
 FOR ALL SCRIPTS:
*NOKEY     NKFLAG=1 ,
*UNDER     IF(J .G. 12) (J=1) 'NEXT ,
           IF(NKFLAG .E. 1) ( SEMBLY='() ) 'NEXT ,
           CCC(REPEAT(1,J),SEMBLY,REPEAT(4,J)),
           NKFLAG=0 , J=J+1 ,
           NEWTOP(ELBAT,TABLE),
           GROUP='2 .
           END)
```

TRAINF SCRIPT

```
(BBBBB     (222222 BBBBB       (
           (1 0) (2) OPL )))
(WAIT      (200000 WAIT        (
           (0) () WAIT )))
(SCRIPT    (80000 SCRPT        (
           (2 SCRIPT) () SCRPT ) AGAIN ))
(GOING BY = PASSES.)
(GOES BY = PASSES.)
(IS PASSING = PASSES.)
(PASSED = PASSES.)
(PASS = PASSES.)
(PASSES    (80 PASS  (
           (0 (* A D) 0 (* A D) 0 DLIST(PASSQ1)) () AGAIN
           (0 (*F C) 0 (*F C) 0 DLIST(PASSQ2)) () AGAIN
           (0) (WHAT PASSES WHAT, AND WHAT IS THE
             SIGNIFICANCE OF THIS.) PASS1 )))
(COINCIDES = COINCIDE.)
(COINCIDED = COINCIDE.)
(COINCIDE (70 COIN (
           (0 (* A D) 0 (* A D) 0 DLIST(COINQ1)) () AGAIN
           (0 (*F C) 0 (*F C) 0 DLIST(COINQ2)) () AGAIN
           (0) (WHAT COINCIDES WITH WHAT, AND WHAT
             IS THE SIGNIFICANCE OF THIS.) PASS1 )))
(NO        (9 NO     (
           (0 DLIST(NOQ)) () AGAIN )))
(YES       (8 YES    (
           (0 DLIST(YESQ)) () AGAIN )))
(NOT       (NOT      (
           (0) () NOKEY )))
(PROG      (TRAINF
           TXTPRT(INPUT,STOUTN),
           SVLBL=LABEL,
           LABEL=POPTOP(DAHIN),
           GOTO(LABEL).
*START     IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
           TXTPRT('(CONSIDER THE EMISSION OF THE LIGHT
             SIGNALS.  WHAT IS THE CONDITION WHICH
             DETERMINES WHEN A WILL SEND THE LIGHT
             SIGNAL TOWARD B.),STOUT),
           TTT('(PASSQ1 FA COINQ1 FA O'E FB)).
*FA        TXTPRT('(RIGHT. WHAT IS THE CONDITION WHICH DETERMINES
             WHEN C WILL SEND THE LIGHT SIGNAL TOWARD B.),STOUT),
           TTT('(PASSQ2 FC COINQ2 FC O'E FD)).
*FB        TXTPRT('(IN OTHER WORDS, HOW WILL A KNOW WHEN TO FLASH
             HIS SIGNAL TOWARD B.),STOUT),
           TTT('(PASSQ1 FD COINQ1 FD O'E FE)).
*FC        TXTPRT('(RIGHT.),STOUT),
           GOTO('FINISH).
*FD        TXTPRT('(WHEN WILL C KNOW WHEN TO FLASH HIS SIGNAL
             TOWARD B.),STOUT),
           TTT('(PASSQ2 FINISH COINQ2 FINISH O'E FE)).
*FE        TXTPRT('(LET ME REPHRASE THE WORDING OF THE PROBLEM.
```

```
                A FLASHES HIS SIGNAL WHEN D PASSES HIM.
                C FLASHES HIS SIGNAL WHEN F PASSES HIM.
                ASSUME THAT THEIR WATCHES ARE SYNCHRONIZED.
                WHEN THEY LATER COMPARED THE TIMES AT WHICH
                THEY SENT THE SIGNALS, THEY FOUND THAT THE TIMES
                WERE THE SAME.  DOES THIS HELP CLARIFY THE
                PICTURE.),STOUT),
              TTT('(YESQ FINISH NOQ FF O'E YSORNO)).
*FF           TXTPRT('(THE POINT IS THAT THE SIGNALS ARE SENT
                WHEN D PASSES A AND WHEN F PASSES C.),STOUT),
              GOTO('FINISH).
*PASS1        IF(TOP(KEESTK) .E. BOT(KEESTK)) 'PRSEMB 'AGAIN .
*SCRPT        PLACE=POPTOP(SEMBLY), SCRNAM=POPTOP(SEMBLY),
*CHANGE       GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH       :REACHED END OF THIS LEVEL OF DISCUSSION-
               CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
              IF(LEMPTY(STORE))
                :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
                'WHERE
                :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
                ( SUBSCR=1 ) ,
              GOTO('CHANGE).
*WHERE        GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB       TXTPRT(SEMBLY,STOUT).
*YSORNO       TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
              NEWTOP(ELBAT,TABLE).
*AGAIN        KKK(KEESTK).
*NP           TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL          EVAL(SEMBLY).
*WAIT         GROUP='1, NEWTOP('WAIT,DAHIN).
*NOKEY        NKFLAG=1,
*UNDER        GROUP='1 , NEWTOP('UNDER,DAHIN).
              END)
```

TRAING SCRIPT

```
(BBBBB    (222222 BBBBB        (
          (1 0) (2) OPL )))
(WAIT     (200000 WAIT         (
          (0) () WAIT )))
(SCRIPT   (80000 SCRPT         (
          (2 SCRIPT) () SCRPT ) AGAIN ))
(NO       (9 NO      (
          (0 DLIST(NOQ)) () AGAIN)))
(YES      (8 YES     (
          (0 DLIST(YESQ)) () AGAIN)))
(NOT      (NOT       (
          (0) () NOKEY)))
(PROG     (TRAING
          TXTPRT(INPUT,STOUTN),
          SVLBL=LABEL,
          LABEL=POPTOP(DAHIN),
          GOTO(LABEL).
*START    IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
          TXTPRT('(WHAT ARE YOUR REASONS FOR SAYING THAT
            E WILL SEE THE SIGNALS SIMULTANEOUSLY.)STOUT),
          TTT('(O'E GA)).
*GA       TXTPRT('(AS A MATTER OF FACT, E WILL NOT SEE THE
            SIGNALS SIMULTANEOUSLY.  SINCE E IS TRAVELLING
            TOWARD THE LIGHT SIGNAL FROM C AND AWAY FROM
            THE LIGHT SIGNAL FROM A, HE WILL SEE THE SIGNAL
            FROM C FIRST.),STOUT),
          TXTPRT('(WOULD YOU LIKE THIS SHOWN BY GRAPHS.),STOUT),
          TTT('(YESQ GB NOQ GC O'E YSORNO)).
*GB       TXTPRT(XECOM('(PRINT GRAPH TWO)),STOUTN),
          TXTPRT(XECOM('(PRINT GRAPH THREE)),STOUTN),
*GC       TXTPRT('(WHAT DON'T YOU UNDERSTAND ABOUT
            THIS PROBLEM.),STOUT),
          TTT('(O'E GD)).
*GD       GROUP='1 , NEWTOP('CHOOSE,DAHIN).
*SCRPT    PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE   GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH   :REACHED END OF THIS LEVEL OF DISCUSSION-
           CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
          IF(LEMPTY(STORE))
            :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
            'WHERE
            :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
            ( SUBSCR=1 ) ,
          GOTO('CHANGE).
*WHERE    GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB   TXTPRT(SEMBLY,STOUT).
*YSORNO   TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
          NEWTOP(ELBAT,TABLE).
*AGAIN    KKK(KEESTK).
*NP       TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL      EVAL(SEMBLY).
*WAIT     GROUP='1 , NEWTOP('WAIT,DAHIN).
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*NOKEY     NKFLAG=1,
*UNDER     GROUP='1 , NEWTOP('UNDER,DAHIN).
           END)
```

TRAINH SCRIPT

```
(BBBBB     (222222 BBBBB (
           (1 0) (2) OPL )))
(WAIT      (200000 WAIT (
           (0) ()  WAIT )))
(TRAIN     (90 TRAIN (
           (0 GROUND 0 DLIST(TRNQ1)) () AGAIN
           (0 DLIST(TRNQ2)) (ABOUT THE TRAIN FRAME)
             UNDER )))
(GROUND    (80 GRND  (
           (0 DLIST(GRNDQ1)) (ABOUT THE GROUND FRAME)
             UNDER)))
(BOTH      (70 BOTH  (
           (0 DLIST(BOTHQ1)) () AGAIN )))
(SCRIPT    (80000 SCRPT        (
           (2 SCRIPT) () SCRPT ) AGAIN ))
(NO        (9 NO      (
           (0 DLIST(NOQ)) () AGAIN)))
(YES       (8 YES     (
           (0 DLIST(YESQ)) () AGAIN)))
(NOT       (NOT       (
           (0) () NOKEY)))
(PROG      (TRAINH
           TXTPRT(INPUT,STOUTN),
           SVLBL=LABEL,
           LABEL=POPTOP(DAHIN),
           GOTO(LABEL).
*START     IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
           TXTPRT('(I HAVE SAID THAT A AND C HAVE SYNCHRONIZED
             WATCHES.  WOULD IT BE POSSIBLE TO SYNCHRONIZE
             THE WATCHES OF A AND D TO READ THE SAME TIME.),
             STOUT),
           TTT('(NOQ HA YESQ HB O'E YSORNO)).
*HA        TXTPRT('(CORRECT.),STOUT),
           GOTO('FINISH), :LATER PUT IN MORE:
*HB        TXTPRT('(HOW WOULD YOU DO THIS.),STOUT),
           TTT('(O'E HC)).
*HC        TXTPRT('(IF THEY ARE SYNCHRONIZED AT ONE SPECIFIC
             TIME, WILL THEY REMAIN SYNCHRONIZED FOR
             LATER TIMES.),STOUT),
           TTT('(NOQ HD YESQ HE O'E YSORNO)).
*HD        TXTPRT('(THEN THE WATCHES OF A AND D
             CANNOT BE SYNCHRONIZED.),STOUT),
           GOTO('FINISH).
*HE        TXTPRT('(WRONG. CONSIDER THE LORENTZ
             TRANSFORMATION EQUATION-),STOUT),
           TXTPRT('( T' = G * (T - (B * X)/C) ),STOUT),
           TXTPRT('(X CAN BE THE POSITION OF OBSERVER A
             IN THE GROUND FRAME.  THIS REMAINS FIXED.
             AS T INCREASES, T' WILL INCREASE BY A
             FACTOR OF G.),STOUT),
*HE1       TXTPRT('(WHICH FRAME DOES THIS ARGUMENT TAKE
             TO BE STATIONARY.),STOUT),
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            TTT('(GRNDQ1 HF TRNQ1 HH BOTHQ1 HH TRNQ2 HG)).
*HF         TXTPRT('(CORRECT.),STOUT),
            NEWTOP('HD,DAHIN).
*HG         TXTPRT('(COULD THE SAME EQUATION BE USED
              TAKING THE TRAIN FRAME TO BE STATIONARY,
              AND SOLVING FOR T.),STOUT),
            TTT('(YESQ HI NOQ HF O'E YSORNO)).
*HH         TXTPRT('(WRONG. THE EQUATION GIVEN IS FOR THE
              TRANSFORMATION OF GROUND COORDINATES TO
              TRAIN TIME. IT WOULD BE USED BY AN OBSERVER
              IN THE GROUND FRAME TO CALCULATE WHAT HE
              WOULD MEASURE AS THE PASSAGE OF TRAIN
              TIME.),STOUT),
            GOTO('FINISH).
*HI         TXTPRT('(WRONG. LET'S CONSIDER THE PRINCIPLE
              OF RELATIVITY FOR A MINUTE.),STOUT),
            NEWTOP('(HJ TRAINH),STORE),
            PLACE='BEGIN, SCRNAM='TRAINJ,
            GOTO('CHANGE).
*HJ         TXTPRT('(LET'S GO BACK TO THE ARGUMENT
              RELATING T AND T'.),STOUT),
            NEWTOP('HE1,DAHIN).
*SCRPT      PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE     GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH     :REACHED END OF THIS LEVEL OF DISCUSSION-
             CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
            IF(LEMPTY(STORE))
              :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
              'WHERE
              :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
              ( SUBSCR=1 ) ,
            GOTO('CHANGE).
*WHERE      GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB     TXTPRT(SEMBLY,STOUT).
*YSORNO     TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
            NEWTOP(ELBAT,TABLE).
*AGAIN      KKK(KEESTK).
*NP         TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL        EVAL(SEMBLY).
*WAIT       GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY      NKFLAG=1,
*UNDER      GROUP='1 , NEWTOP('UNDER,DAHIN).
            END)
```

TRAINI SCRIPT

```
(BBBBB     (222222 BBBBB (
           (1 0) (2) OPL )))
(WAIT      (200000 WAIT (
           (0) () WAIT )))
(SCRIPT    (80000 SCRPT          (
           (2 SCRIPT) () SCRPT ) AGAIN ))
(NO        (9 NO                 (
           (0 DLIST(NOQ)) () AGAIN)))
(YES       (8 YES                (
           (0 DLIST(YESQ)) () AGAIN)))
(NOT       (NOT                  (
           (0) () NOKEY)))
(PROG      (TRAINI
           TXTPRT(INPUT,STOUTN),
           SVLBL=LABEL,
           LABEL=POPTOP(DAHIN),
           GOTO(LABEL).
*START     IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
           TXTPRT('(IS IT TRUE THAT 'SIMULTANEITY' HAS A
             MEANING WHICH IS DIFFERENT IN THE TRAIN
             FRAME AND IN THE GROUND FRAME.),STOUT),
           TTT('(NOQ IA YESQ IB O'E YSORNO)).
*IA        TXTPRT('(CONSIDER THE FOLLOWING DERIVATION.),STOUT),
           TXTPRT(XECOM('(PRINT EQN ONE)),STOUTN),
           TXTPRT('(THUS, TWO EVENTS WHICH OCCUR AT
             THE SAME TIME IN THE GROUND FRAME, ARE
             OBSERVED TO OCCUR AT DIFFERENT TIMES
             IN THE FRAME OF THE TRAIN.  DO YOU
             UNDERSTAND THIS NOW.),STOUT),
           TTT('(YESQ IB NOQ IA1 O'E YSORNO)).
*IA1       NEWTOP('(IB TRAINI),STORE),
           PLACE='BEGIN, SCRNAM='TRAINH, GOTO('CHANGE).
*IB        TXTPRT('(WHAT IF D AND F AGREE THAT TWO EVENTS
             OCCUR SIMULTANEOUSLY IN THE TRAIN FRAME. WOULD
             A AND C OBSERVE THEM SIMULTANEOUSLY.),STOUT),
           TTT('(NOQ IC YESQ ID O'E YSORNO)).
*IC        TXTPRT('(SO WE HAVE SEEN THAT MEASURED TIME IS
             DIFFERENT IN DIFFERENT INERTIAL FRAMES OF
             REFERENCE.),STOUT),
           TRSEND=1 ,
           :END OF TRAINI CONVERSATION:
           GOTO('FINISH).
*ID        TXTPRT('(REMEMBER THAT BECAUSE OF THE
             PRINCIPLE OF RELATIVITY, YOU CANNOT SAY THAT
             ANY INERTIAL FRAME OF REFERENCE HAS AN ABSOLUTE
             QUALITY ABOUT IT.  INERTIAL FRAMES ARE RELATIVE.
             ),STOUT), GOTO('IC).
           TTT('(YESQ IE NOQ IG O'E YSORNO)).
*IE        TXTPRT('(GOOD.),STOUT),
           GOTO('IC).
*IG        :GO TO TRAINJ AS A SUB SCRIPT TO DISCUSS THE
            RELATIVE QUALITY OF INERTIAL FRAMES:
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          NEWTOP('(IC TRAINI),STORE),
          PLACE='BEGIN, SCRNAM='TRAINJ, GOTO('CHANGE).
*SCRPT    PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE   GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH   :REACHED END OF THIS LEVEL OF DISCUSSION-
           CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
          IF(LEMPTY(STORE))
            :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
            'WHERE
            :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
            ( SUBSCR=1 ) ,
          GOTO('CHANGE).
*WHERE    GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB   TXTPRT(SEMBLY,STOUT).
*YSORNO   TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
          NEWTOP(ELBAT,TABLE).
*AGAIN    KKK(KEESTK).
*NP       TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL      EVAL(SEMBLY).
*WAIT     GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY    NKFLAG=1,
*UNDER    GROUP='1 , NEWTOP('UNDER,DAHIN).
          END)
```

TRAINJ SCRIPT

```
(BBBBB      (222222 BBBBB (
            (1 0) (2) OPL )))
(WAIT       (200000 WAIT          (
            (0) () WAIT )))
(SCRIPT     (80000 SCRPT          (
            (2 SCRIPT) () SCRPT ) AGAIN ))
(NO         (9 NO                 (
            (0 DLIST(NOQ)) () AGAIN)))
(YES        (8 YES                (
            (0 DLIST(YESQ)) () AGAIN)))
(NOT        (NOT                  (
            (0) () NOKEY)))
(PROG       (TRAINJ
            TXTPRT(INPUT,STOUTN),
            SVLBL=LABEL,
            LABEL=POPTOP(DAHIN),
            GOTO(LABEL).
*START      IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
            TXTPRT('(WOULD IT HAVE MADE ANY DIFFERENCE
              IN THE DISCUSSION OF THE PROBLEM IF
              THE GROUND FRAME HAD BEEN DESCRIBED AS
              ANOTHER TRAIN FRAME-),STOUT),
            TXTPRT(XECOM('(PRINT GRAPH TEN)),STOUTN),
            TXTPRT('(WITHOUT ANY REFERENCE TO THE
              RELATIONSHIP OF THESE FRAMES TO THE
              EARTH FRAME.),STOUT),
            TTT('(NOQ JA YESQ JB O'E YSORNO)).
*JA         TXTPRT('(RIGHT.),STOUT),
*JA1        TXTPRT('(AS FAR AS THE PROBLEM IS CONCERNED,
              THE GROUND FRAME SHOULD BE CONSIDERED AS
              AN INERTIAL FRAME WITH NO SPECIAL
              QUALITIES.),STOUT),
            GOTO('FINISH).
*JB         TXTPRT('(WHAT WOULD THE DIFFERENCE BE
              BETWEEN THE TWO.),STOUT),
            TTT('(O'E JC)).
*JC         TXTPRT('(IS THERE ANYTHING SPECIAL ABOUT THE
              INERTIAL FRAME OF THE EARTH OTHER THAN THE
              FACT THAT IN OUR EVERYDAY EXPERIENCE WE
              THINK OF IT AS BEING AT REST.),STOUT),
            TTT('(NOQ JA YESQ JD O'E YSORNO)).
*JD         TXTPRT('(WHAT IS SPECIAL.),STOUT),
            TTT('(O'E JE)).
*JE         TXTPRT('(THE ONLY DIFFERENCE BETWEEN THE
              FRAMES OF REFERENCE IS THE DIRECTION OF
              MOTION, SINCE THEY ARE BOTH INERTIAL
              FRAMES.),STOUT),
            GOTO('JA1).
*SCRPT      PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE     GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH     :REACHED END OF THIS LEVEL OF DISCUSSION-
             CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
```

```
          IF(LEMPTY(STORE))
            :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
            'WHERE
            :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
            ( SUBSCR=1 ) ,
          GOTO('CHANGE).
*WHERE    GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB   TXTPRT(SEMBLY,STOUT).
*YSORNO   TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
          NEWTOP(ELBAT,TABLE).
*AGAIN    KKK(KEESTK).
*NP       TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL      EVAL(SEMBLY).
*WAIT     GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY    NKFLAG=1,
*UNDER    GROUP='1 , NEWTOP('UNDER,DAHIN).
          END)
```

TRAINK SCRIPT

```
(BBBBB    (222222 BBBBB (
          (1 0) (2) OPL )))
(WAIT     (200000 WAIT (
          (0) () WAIT )))
(DISTANCE (90 DIST             (
          (0 DLIST(DISTQ1))
            (ABOUT DISTANCE) UNDER)))
(LENGTH   (91 LENG             (
          (0 DLIST(LENGQ1)
            (ABOUT LENGTH) UNDER)))
(DIRECTION OF MOTION           (40 DOM       (
          (0 DLIST(DOMQ1))
            (ABOUT THE DIRECTION OF MOTION) UNDER)))
(SCRIPT   (80000 SCRPT         (
          (2 SCRIPT) () SCRPT ) AGAIN ))
(NO       (9 NO                (
          (0 DLIST(NOQ)) () AGAIN)))
(YES      (8 YES               (
          (0 DLIST(YESQ)) () AGAIN)))
(NOT      (NOT                 (
          (0) () NOKEY)))
(PROG     (TRAINK
          TXTPRT(INPUT,STOUTN),
          SVLBL=LABEL,
          LABEL=POPTOP(DAHIN),
          GOTO(LABEL).
*START    IF(PLACE .E. 'BEGIN) 'NEXT PLACE ,
          TXTPRT('(WHAT ELSE WILL APPEAR DIFFERENT WHEN
            VIEWED BY AN OBSERVER IN THE TRAIN FRAME
            OF REFERENCE.),STOUT),
          TTT('(DISTQ1 KD DOMQ1 KE O'E KF)).
*KD       PLACE='BEGIN, SCRNAM='TRAIND, GOTO('CHANGE).
*KE       TXTPRT('(THAT IS TRUE. WHAT ELSE WILL BE
            DIFFERENT.),STOUT),
          NEWTOP(ELBAT,TABLE).
*KF       TXTPRT('(WHAT IN ADDITION TO TIME IS A
            BASIC MEASURED QUANTITY INVOLVED IN THIS
            PROBLEM.),STOUT),
          TTT('(DISTQ1 KD DOMQ1 KE O'E KG)).
*KG       TXTPRT('(THE ANSWER I AM LOOKING FOR IS
            DISTANCE OR LENGTH.),STOUT),
          GOTO('KD).
*SCRPT    PLACE=POPTOP(INPUT), SCRNAM=POPTOP(INPUT),
*CHANGE   GROUP='1 , KEESTK=KA, NEWTOP('CHANGE,DAHIN).
*FINISH   :REACHED END OF THIS LEVEL OF DISCUSSION-
           CHECK TO SEE IF ON A SUB SCRIPT LEVEL:
          IF(LEMPTY(STORE))
            :TRUE-GO TO GENERAL SECTION FOR DIRECTIONING:
            'WHERE
            :FALSE-COMING BACK FROM SUB SCRIPT LEVEL:
            ( SUBSCR=1 ) ,
          GOTO('CHANGE).
```

```
*WHERE     GROUP='1 , KEESTK=KA, NEWTOP('WHERE,DAHIN).
*PRSEMB    TXTPRT(SEMBLY,STOUT).
*YSORNO    TXTPRT('(PLEASE ANSWER EITHER YES OR NO.),STOUT),
           NEWTOP(ELBAT,TABLE).
*AGAIN     KKK(KEESTK).
*NP        TXTPRT('(NOT PROGRAMMED),STOUT).
*OPL       EVAL(SEMBLY).
*WAIT      GROUP='1 , NEWTOP('WAIT,DAHIN).
*NOKEY     NKFLAG=1,
*UNDER     GROUP='1 , NEWTOP('UNDER,DAHIN).
           END)
```

TRAINL SCRIPT

```
(PROG      (TRAINL
           GOTO(POPTOP(DAHIN)).
*START     GROUP='1 ,
           SCRIPT(SA,'TRAINE),
           PLACE='BEGIN,
           NEWTOP(PLACE,DAHIN).
           END)
```