COMPUTER ASSISTED INSTRUCTION FOR THE "C" PROGRAMMING LANGUAGE ON THE ZENITH Z-100 MICROCOMPUTER SYSTEM

THESIS

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Captain, USAF

AFIT/GCS/MA/85D-2

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Wright-Patterson Air Force Base, Ohio
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Presented to the Faculty of the School of Engineering of the Air Force Institute of Technology Air University
In Partial Fulfillment of the Requirements for the Degree of Master of Science

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December 1985

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Preface

The purpose of this study was to develop a computer assisted instruction (CAI) program package for use on the Zenith Z-100 microcomputer system. The package is designed to give programming students introductory information on the "C" programming language. This programming package is to be used in the training programs managed by the Computer Assisted Instruction Plans Branch of the 3300 Technical Training Wing at Keesler AFB, Mississippi.

I would like to express my sincere thanks to my thesis advisor, Dr. Henry B. Potoczny, who gave me guidance and encouragement throughout my thesis effort. Thanks is also extended to Captain Patricia Lawlis, who as my thesis reader provided many constructive comments on improving this thesis. Grateful appreciation is also extended to the sponsor my thesis, the CAI Plans Branch at Keesler AFB, and in particular, Captain Glen A. Miller and Technical Sergeant Charles T. Neal, who provided help in the verification and validation of the programs and course material I developed.

Finally, I want to express special gratitude to my wife Anne and my children Crystal and Bryan. They have forfeited countless hours of time with me in order that I could complete my graduate work here at AFIT. Their patience, understanding, and devoted love gave me the strength I needed to overcome the many obstacles I encountered. I owe them a debt that will take a lifetime to repay.
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Abstract

The field known as "computer assisted instruction" or "CAI" as it is commonly called, has gained considerable interest and support since the advent of the microcomputer. More and more people, including those in supervisory positions are beginning to see the advantages, both cost and time, in having training available in the workplace. This study developed a training package for use on the Zenith Z-100 microcomputer. The package consists of six lessons and three programs. The six lessons cover various topics dealing with the "C" programming language. The objective of these lessons is to present an introduction to the "C" programming language. The three programs are written in the Pascal programming language and are used for the following functions:

1. Provide a means of displaying the lesson material.
2. Provide a means of checking student progress.
3. Provide a means of displaying course statistics.
Computer Assisted Instruction for the "C" Programming Language on the Zenith Z-100 Microcomputer System

I. Introduction

Background

The use of Computer Assisted Instruction (CAI) to help in the training needs of the Services has increased with the introduction of microcomputer systems into the workplace. The development of CAI courses for use on these computer systems has been lagging behind the need for training on the new systems. The CAI development process involves a working knowledge of the system to present the material as well as a knowledge of the subject to be presented. The presentation of the developed CAI course is usually controlled by means of some type of presentation program. Manpower and time constraints may prohibit development of such a program and indicate the need to utilize a commercially developed authoring/presentation system.

The use of a commercial authoring system requires that a coursewriter learn that specific authoring system for use on a specific microcomputer system. The coursewriter can then devote his attention to the development of the course subject material. The subject topics that typically are identified as of primary importance include: word processing, data base management, spreadsheets, operating systems, and programming languages.
Statement of Problem

The problem to be solved is as follows: How can a computer assisted instruction (CAI) course be written and implemented to teach the "C" programming language on the Zenith Z-100 microcomputer system without the use of a commercial authoring/presentation system? The course will be of sufficient length to instruct the beginning student to a level that will allow him/her to program using the "C" programming language. The course subject will be broken into lesson topics which are made up of subsections of the lesson topic.

Each lesson will:

1. Give the student the ability to select between being shown the complete lesson or only reviewing certain parts.

2. Have the ability to sample student comprehension during lesson presentation by means of questions.

3. Have the ability to branch, at appropriate times, to other parts of the lesson.

4. Give the student a chance to review subsections before being tested on the lesson material.

5. Have the ability to test the student on the presented material after lesson completion.

6. Have the ability to allow for review of subsections before retesting (in the case of lesson failure).

In addition to the above, a record will be kept of student responses, both during the presentation of the lessons and the tests, for later statistical analysis and
display. This is done in order to be able to identify areas of the course that perhaps are not teaching the material as intended and/or are causing the student difficulties.

**Scope**

The scope of this thesis effort is to design, implement, test, and validate a CAI course for presenting information on the "C" programming language. The design phase will incorporate top down structured programming techniques.

Although it is not the primary purpose of this thesis, a method for developing the textual material and presenting that material will necessarily be created. This added benefit arises from the fact that no commercially available authoring/presentation software will be used. This opens up the possibility of developing other courses using programs written during this thesis effort.

The end result of this thesis is to develop a CAI course that will be acceptable to the sponsor at Keesler AFB, who will then distribute the course to all interested training managers throughout the Services.

**Assumptions**

It is assumed that the students who will use this CAI course will have a working knowledge of the operation of the Zenith Z-100 microcomputer system that this course is designed to run on. This Z-100 system is the standard system purchased by government contract through Zenith Data
Systems, namely, the 192K byte, two 5.25 inch disk drive system. Although it would be of some benefit, there isn't any requirement that students taking this CAI course have access to a "C" compiler.

General Approach

The first step in this endeavor is to do research into the techniques of teaching with a computer. The purpose here is to broaden the teaching base from which to build the overall course presentation. Once the methods of presenting the material are well in hand, the course material will be researched to establish a firm background from which to teach. The next step is to write the individual lessons and develop the program to present them. A program will then be developed to do the statistical analysis and display.

Following the research and development phase will be the implementation of the system. This phase will consist of putting all the pieces into a cohesive package that will accomplish the goal of the study, namely, use the Zenith Z-100 computer system to present a CAI course on the "C" programming language.

In order to ensure the development and implementation of a quality product, an extensive testing and validation system will be incorporated throughout the study. The ultimate test will come when the sponsor at Keesler AFB tests the course against their well-established standards.
II. Methodology

The Aim of CAI

The overall aim of Computer Assisted Instruction (CAI) is, naturally, to use a computer system to assist in the training of individuals in a given subject.

In its most common form, CAI is very similar to a programmed text. The subject material is presented to the student, questions are asked of the student, answers are evaluated, and a decision is made as to what material is shown next. If the questioning indicates that the student understands the material, new material is shown. If the student seems to be having trouble with a particular part of the lesson, a branch can be made to supplemental material to help the student understand. Other forms of CAI use simulation and/or emulation techniques. These methods of instruction are very useful when teaching a specific performance process but not for such things as computer programming. Since it is the intent of this thesis effort to teach a programming language, the method used will closely resemble that of programmed text.

Advantages of CAI

There are many advantages to CAI, the following are but a few of the more important ones: Standardization, time efficiency, availability, flexibility, modularity, and cost efficiency.
Each of these advantages contribute to the overall attractiveness of using CAI as a method of training. Standardization is accomplished by programming the subject material into the computer. In this way, each and every student who takes a given course will receive the same information. The unfortunate human flaw of a human teacher forgetting to mention some important detail is thus avoided.

The use of CAI can save time by allowing students to progress at their own rate. This is opposed to the alternative of locking them into a classroom setting and controlling the pace of the class as a whole. This leads us to another of the advantages, that of availability. Since the CAI course is conducted on a microcomputer system, the course is virtually available at all times. This means that many training requirements can be accomplished without the student having to leave his/her work area. Hence you have flexibility (another advantage) in scheduling training. Since the course is available at all times, training can be scheduled around work requirements.

The actual construction of a well developed CAI package should allow for the accessing of information in a rapid way. This usually calls for the development of sections of the course in small modules. In this way the student doesn't necessarily need to complete an entire course to get at the information that pertains to his/her job requirements. The CAI course developed in this thesis follows this modular course concept. The course in broken into lessons
which are each broken into topics.

The last advantage mentioned is that of cost effectiveness. By taking the previous advantages into consideration it is easy to see how using CAI can achieve a cost effective training program. Training can be conducted whenever workload requirements allow the student enough free time to take CAI lessons. The need for the student to travel to some other location for needed training can also be reduced.

Disadvantages of CAI

There are of course drawbacks to everything, and CAI is no exception. A few of the disadvantages follow: System availability, Uni-directional training, acceptability.

The availability of the computer system for training purposes can restrict the usefulness of the CAI system. The primary reasons for system nonavailability are: Operational requirements and maintenance downtime. An organization's operational requirements may be such that a computer system cannot be spared in order to accomplish a training requirement in a timely manner. Obviously, if a computer system is down for maintenance, training cannot be accomplished using that system.

The second disadvantage involves the inability of the students to ask questions of their trainer. This requires the student to concentrate hard on the presented material in order to ensure the required understanding. Since the student doesn't (usually) have the ability to query the compu-
ter on a point that may be causing him/her problems, the student must seek out someone who knows the subject in order to receive clarification. This of course is not all bad, since this will lead to better communication in the work place.

Lastly, CAI is not completely accepted by management personnel as an alternative to classroom instruction. Formal classroom instruction has been used for so long that many believe it to be the only effective means of accomplishing required training.

Development Considerations

There are several design considerations to take into account when coming up with a methodology for CAI course development. The first of these and perhaps the most important is the objective of what is to be taught. As stated before, the objective of this study is to create a means of presenting information on the "C" programming language on the Z-100 microcomputer system. The second consideration is the resources available for training. The necessary resources for taking the course developed in this study is any microcomputer system that runs under the MS-dos operating system. The primary system will be the Zenith Z-100. The third consideration is the teaching technique to be used. As stated earlier, this will most closely resemble a programmed text presentation. The last major development consideration is course validation. In addition to initial
development validation, the CAI package will provide a means of recording student progress and provide for statistical collection of student responses to all questions throughout the course. These capabilities will be described in detail later in the study.

Course Development Approach

The general approach to developing this CAI was to write a program which would keep track of as many as twenty students as well as present the material to the student in short topic sessions. The student has total control over which topics he/she views. The presentation program is written in the PASCAL programming language and is easy to modify in the case of any future enhancements. Two additional programs, both written in PASCAL, have been included in the package. The purpose of the first is to produce a report of the current student status for each registered student on a given student disk. The purpose of the second is to produce a report of the statistics collected on the student responses during course presentation. More detailed information can be found in Chapter 3.
III. Design Specification

General Description

The purpose of this computer assisted instruction (CAI) package is to provide a means of presenting introductory information on the "C" programming language. The material to be presented is to be stored in separate lesson files on one five and one quarter inch floppy disk that has been formatted using the MS-DOS "format" program. The lesson files are to be created using any text editor that will run under MS-DOS. The lessons are to be broken into topic sections that the student can complete in a relatively short period of time. Three programs will be provided with the CAI package and a description of these follows.

CAI Program

The main program contained in the CAI package is the one that will present the course material to the student. This program will read and display several files automatically in addition to reading and displaying the student's chosen subject material. This program will keep a record of student progress through the course as well as write to a statistical collection file to be used for future course validation and improvements.

Lesson Files. The main CAI program will have access to six lesson files which contain the course material. Each of these lesson files will contain introductory information for its particular lesson material. An associated menu is also
included for display, allowing the student to choose the topic material to be shown.

Other Files. In addition to the lesson files discussed above, there are five other files to be used by the main CAI program. First, there is to be a file that contains introductory comments to the student. This file will be kept short since it is to be seen each and every time the program is executed. Second, there is to be a main menu file that will allow the student to choose which of the six lessons they want to enter. This file will be restricted to one screen in size. Third, there is to be a file that contains program conclusion comments. This file will also be kept short and is only to serve as a means of assuring the student that they have correctly terminated the program. Fourth, there is to be a file that will store data on as many as twenty students. This file is where each student's progress through the course is to be kept and will be keyed on a unique student identification number. Lastly, there is to be a file that will store data for each question displayed during course presentation. This file will be used for ongoing course improvements.

Status Program

The status program will be provided for use by the training monitor. Its whole purpose is to provide a means of viewing each student's record in order to determine their status in the course. A report is to be generated giving
the unique student identification number and listing all
lessons that have been successfully passed. The program
will allow for the possibility of the training monitor
having merged several student record files into one file.
The program will also format the report for either screen
display or hardcopy printout.

"STUDENT" File. The file to be read by the status pro-
gram is to contain student identification numbers, student
names, as well as lesson and topic status data. An active
student file will contain at most twenty unique student
records. As mentioned earlier, several student files may be
merged into one student file prior to running the status
program.

Statistics Program

A statistics program will be provided for use by the
office of primary responsibility (OPR) at Keesler AFB. This
program is to provide a means of analyzing the data
collected on questions presented during each training
session. A report is to be generated giving information
such as lesson number, frame number, number of responses for
each of the valid responses, number of right responses,
number of wrong responses, percent of right responses, and
percent of wrong responses. The results of the statistical
analysis is to be displayed in either of two formats:
screen display or hardcopy printout.
"STATS" File. The file to be read by the statistics program is to contain such items as lesson number, topic number, frame number, correct answer, and the student's response. Again, several of these files may be merged into one file prior to running the statistical program.
IV. System Implementation

General Description

The implementation of this computer assisted instruction (CAI) training package involved the development of lesson material covering six major subject areas. The development of these lessons was accomplished in conjunction with the development and validation of the three programs specified in chapter three. This chapter presents a brief description of each major component of the CAI training package. Copies of these components are provided in appendixes B and C.

"C" Lessons Descriptions

The following is a breakdown of the subject material as presented in the "C" CAI course:

Lesson One. Lesson one contains introductory information on the course and some general information on "C" programming. The lesson is broken into four subtopics and a lesson test. The first subtopic gives a short introduction to the overall course structure and some of the particulars used in the course. The second subtopic discusses the overall organization and structure of a typical C program. The third subtopic gives a description of the overall C programming environment covering such items as "compiling" and "linking". The forth subtopic states a problem to be solved and presents a solution to help introduce the student to C program statements.
Lesson Two. Lesson two contains information on variables, constants, operators, and expressions used in C programming. The lesson is broken into four subtopics and a lesson test. The first and second subtopics cover the declaration and use of variables and constants. The third and forth subtopics cover the use of the different operators and expressions in C programming.

Lesson Three. Lesson three contains information on program control statements used in C programming. The lesson is broken into four subtopics and a lesson test. The first subtopic gives descriptions of the structure and use of the "if" and "if-else" control statements and how to "nest" these statements along with a description of the "switch" control statement. The second subtopic discusses the structure and use of loop statements (while, for, and do-while). The third subtopic gives a description of the "break" and "continue" statements and how they are used. The forth subtopic gives a description of the "goto" statement and the use of "labels" within a C program.

Lesson Four. Lesson four contains information on arrays, pointers, and address arithmetic used in C programming. The lesson is broken into four subtopics and a lesson test. The first subtopic introduces the declaration, initialization, and use of arrays. The second subtopic introduces the declaration and use of pointers. The third and forth subtopics cover how to work with pointers and includes topics such as how pointers are passed to functions, how pointers...
are used in conjunction with arrays, and how to use address arithmetic.

**Lesson Five.** Lesson five contains information on structures that are used in C programming. The lesson is broken into four subtopics and a lesson test. The first subtopic introduces the idea of structures and two methods of their declaration. The second subtopic describes the use of structures within structures and arrays of structures. The third subtopic describes how to use pointers in conjunction with structures. The forth subtopic describes how structures are passed between functions.

**Lesson Six.** Lesson six contains introductory information on input and output capabilities of the C language. The lesson is broken into four subtopics and a lesson test. The first subtopic gives a description of the use of the standard I/O functions "getchar" and "putchar". The second subtopic gives a description of the use of the standard input function "getline". The third subtopic gives a description and examples of the standard input function "scanf". The forth subtopic gives a description and examples of the standard output function "printf".

**CAI Program**

Program CAI is the program that is used to present the lesson material to the student. The program is designed to present any lesson material that is in the same format as the lessons developed in this thesis. Therefore, additional
courses may be written for presentation on the Zenith Z-100 by this program. The following is a breakdown and brief description of the program.

**Structure Charts.** The program is broken into a main program and 17 procedures, all of which are written in the Pascal programming language. Structure charts of this program are presented in Figures 4.1 thru 4.8 of this chapter.

**Flow Description.** The flow of this program follows a very logical structured path. The program begins by presenting an introductory message from file "INTRO". The student is next queried for their unique student identification number. A search is then made of file "STUDENT" (which has been read into memory) and if no match is found (a new student) the student is queried for their name and unique student identification number they wish to use from this point on. Next, the student is presented a menu of lessons from which to choose (file "MENU"). Once a selection is made, introductory information for the chosen lesson is displayed and another menu is presented giving the student a choice of lesson subtopics. Once the student chooses a lesson subtopic, the topic is read into memory and topic presentation begins. When the topic is completed, an update of the CAI statistical collection file as well as the students progress record file is made. The student is then returned to the subtopic selection menu, where if the student wishes, he/she may exit to the lesson selection menu, where if the student wishes, he/she may exit the program.
Figure 4.1 CAI - Main
Figure 4.7: CAI - Mquestion

- Question
- FrameHeader
- ClearScreen

4 - 11
Figure 4.8 CAI - Pquestion
Status Program

Program Student_Status is the program that is used to present the current student status for all students recorded in file "STUDENT". The program is designed to accept and present any number of student records. This provides for the merging of several student files prior to running the program. There are two output formats for this program, "screen" and "hardcopy". The following is a breakdown and brief description of the program.

Structure Chart. The program is broken into a main program and five procedures, all of which are written in the Pascal programming language. A structure chart of this program is presented in Figure 4.9 of this chapter.

Flow Description. The flow of this program follows a straightforward path. The program begins by asking the user for the preferred method of report format, choices are either "screen" or "hardcopy". A header is then displayed and is followed by the student progress information. The structure of the report is in the format of "student identification number" followed by the word "passed" for every lesson that the student has successfully completed.
Figure 4.9 Student Status - Main

1: choice
2: character
3: student count
4: advance
Statistics Program

Program CAI_Statistics is the program that is used to present the statistics collected on all questions asked during all course presentation sessions. The purpose of the program is to provide a means for the office of primary responsibility (OPR) at Keesler AFB to verify course content and effectiveness. The program is designed to accept and present statistics on as many as 150 different question frames. This restriction can be overcome by changing one line of source code (a constant value), if it becomes necessary. Several "STATS" files can be combined (and should be) before running this program. There are two output formats for this program, "screen" and "hardcopy". The following is a breakdown and brief description of the program.

Structure Charts. The program is broken into a main program and eight procedures, all of which are written in the Pascal programming language. Structure charts of this program are presented in Figures 4.10 thru 4.12 of this chapter.

Flow Description. The flow of this program follows a straightforward path. The program begins by asking the user for the preferred method of report format, choices are either "screen" or "hardcopy". A header is then displayed and is followed by internal reading and sorting routines. The output report is displayed in columns, giving all the needed statistics to the user. Items such as percent right and percent wrong help to validate questions.

4 - 15
Figure 4.10 CAI Statistics - Main
Figure 4.12 CAI Statistics - ShowStats

ShowStats

EndScreen

Header

ClearScreen

1.7.3

1.7.3.1

1.3

1.1
V. Conclusions and Recommendations

General Comments

The computer assisted instruction (CAI) package developed, tested, and implemented in this thesis effort presents an introduction to the "C" programming language. Although it does not get deep into fancy "C" language usage, it does serve its primary purpose of providing a strong base from which the student can build his/her "C" programming expertise. With a little initiative, the student will soon have the full power of the language at their disposal.

As was mentioned in chapter one, the primary goal of this study was to develop a course on the "C" programming language to be presented on the Zenith Z-100 microcomputer system. In order to achieve the stated goal a secondary goal had to be met, that of developing a software presentation system for the developed course material. This secondary goal provides the possibility of producing other courses for presentation on the Z-100 system.

Suggestions for Further Study

The existing presentation program is a good one as it stands, but certain enhancements would make it better. One such enhancement would be to add logic to allow for the asking of "fill in the blank" type questions. Another would be to allow the student to backup to a previously seen frame. One improvement in program control would be to read in the first frame of a topic, display it, and then read in
the rest of the topic while the student is reading the first frame. Currently, the student must wait nearly one minute before any topic material is displayed after they have chosen the topic from the topic menu.

Finally, the overall "C" course can be improved in several ways. Two of these are: provide for more branching to supplemental material and cover more of the capabilities of the "C" programming language. The course material and the programs used in conjunction with its use can be an effective means of getting introduced to the wonders of "C" programming.
Appendix A

Users Guide

Using Program "CAI"

Program CAI is the main program of this computer assisted instruction (CAI) package. The executable program is stored on "Disk 1" under the filename CAI.EXE. To start this program running, you need to boot the Zenith Z-100 microcomputer using the MS-DOS operating system. Remove the operating system disk from drive A, place "Disk 1" in drive A and "Disk 2" in drive B. Disk 2 contains the six lesson files of the C CAI course.

Once the disks are in place, type CAI in response to the A> prompt. The main CAI program will begin to execute and will prompt you for any further needed responses. One important item that deserves special mention is the student identification number that you will be prompted for during initial startup. This number is used to keep track of an individual's progress through the course. In order for it to be an effective feature of the package, the same sequence of characters must be entered each time you enter the CAI program.

Using Program "STUDENT STATUS"

Program Student_Status is designed for system training monitors. It is not for use by the students taking the course. This program will produce a report giving the current student status for each student recorded in file
"STUDENT" on "Disk 1". The executable program is stored on "Disk 1" under the filename STATUS.EXE. To start this program running, you need to boot the Zenith Z-100 microcomputer using the MS-DOS operating system. Replace the operating system disk in drive A with "Disk 1" of the CAI package. Once the disk is in place, type STATUS in response to the A> prompt. The Student_Status program will begin to execute and will prompt you for any further needed responses.

Using Program "CAI STATISTICS"

Program CAI_Statistics is designed for the office of primary responsibility (OPR) at Keesler AFB. It is not for use by the students taking the course. This program will produce a report giving statistics on all the C CAI course questions recorded in file "STATS" on "Disk 1". The executable program is stored on "Disk 1" under the filename VALIDATE.EXE. To start this program running, you need to boot the Zenith Z-100 microcomputer using the MS-DOS operating system. Replace the operating system disk in drive A with "Disk 1" of the CAI package. Once the disk is in place, type VALIDATE in response to the A> prompt. The CAI_Statistics program will begin to execute and will prompt you for any further needed responses.
Appendix B

Program Listings

Program "CAI"

(**** THIS PROGRAM WAS WRITTEN IN PARTIAL FULFILLMENT OF A MASTERS THESIS ****)

Date: 8/1/85
Version: 1.0

Title: Program CAI
Filename: CAI.FAS
Coordinator: Capt Frank W. DeMarco
Project: Masters Thesis
Operating System: MS-DOS
Language: Pascal
Use: Compile and link with PASCAL.LIB using MS-Pascal compiler and linker.
Contents: Program CAI - Main Driver.

Procedure ClearScreen - Clears Z-100 terminal screen.
Procedure RegStu - Registers a first time student.
Procedure Query - Reads in "STUDENT" file, prompts student for student identification number, and checks the ID number against current student list.
Procedure StartEnd - Reads and displays files "INTRO" at start of program and "EXIT" at end of program.
Procedure Select - Reads and displays file "MENU", prompts the student for choice of lesson to be shown.
Procedure ShowTopic - Driver of procedures that display topic material.
Procedure BlankLines - Initializes area where topic material is stored to blanks.
Procedure Readlines - Reads in topic that the student chose to view.
Procedure StorePositions - Builds an array of line positions where frames begin within the topic.
Procedure FrameHeader - Displays a frame header for a frame.
Procedure Tframe - Displays a text type frame.
Procedure Qframe - Driver for the procedures that display and handle question type frames.
Procedure Mquestion - Displays and handles multiple choice type question frames.
Procedure Pquestion - Displays and handles pick type question frames (true/false and yes/no).
Procedure RecordStats - Reads file "STATS" and adds statistical data from current session.
Procedure StuFec - Writes updated student course progress data to file "STUDENT".
Procedure StartLesson - Displays topic choices for a lesson, prompts student for choice of topic to be shown. Driver of procedures that display lesson material and update...
* * *

**statistical & student progress files.**

* * *

**Function:** The purpose of this program is to present material on the "C" programming language. It is intended for use by the 3300 Technical Training Wing in support of its mission. The office of primary responsibility for this course is the CAI Plans Branch (3300 TCHTW/TTGXI) at Keesler AFB, MS 39534.

* * *

(**************************************************************************)

**Date:** 8/1/85
**Version:** 1.0

**Name:** program CAI
**Module number:** 1.0
**Description:** Main driver of program
**Passed Variables:** None
**Returns:** None
**Global Variables Used:** studentcount, choice
**Global Variables Changed:** None
**Files Read:** None
**Files Written:** None
**Modules Called:** ClearScreen, StartEnd, Query, Select, StartLesson
**Calling modules:** None

**Author:** Capt Frank W. DeMarco
**History:**
* 1.0 Frank W. DeMarco 8/1/85 - input original code

**************************************************************************

```
program CAI (input, output);

const
MAXSTUDENTS = 20;
MAXLESSONS =  6;
MAXTOPICS =  5;
VLESSON = '6';
VTOPIC = '5';
ALINEP1 = '**************************************************************************';
ALINEP2 = '**************************************************************************';
ABLANKS = '*';
SLANKS = ' ';

type
  file = TEXT;
  roll = record
    studentnumber : packed array [1..11] of char;
    studentname : packed array [1..29] of char;
    lessons : packed array [1..MAXLESSONS] of char;
    topics : array [1..MAXLESSONS, 1..MAXTOPICS] of char;
  end;
roster = array [1..MAXSTUDENTS] of roll;
```

R - 2
Istat = array [1..MAXLESSONS] of char;
displayln = packed array [1..80] of char;
lessonlines = array [1..500, 1..80] of char;
menulines = array [1..22, 1..80] of char;
tstat = array [1..MAXTOPICS] of char;

var
  iomessage, student, statfile, menu, lesson, temp1, temp2 : iofile;
  advance, linecount, studentcount : integer;
  choice, ichoice : char;
  npupil : roll;
  npupil : roster;
  lessonstat : lstat;
  println : displayln;
  lessonln : lessonlines;
  menuln : menulines;
  topicstat : tstat;

begin (* Procedure ClearScreen *)
  write (chr(27), 'H', chr(27), 'J', chr(27), 'w')
end; (* Procedure ClearScreen *)
# Name: procedure RegStu
# Module number: 4.1
# Description: Registers a first time student.
# Passed Variables: None
# Returns: None
# Global Variables Used: npupil, studentcount
# Global Variables Changed: npupil, studentcount
# Files Read: None
# Files Written: None
# Modules Called: ClearScreen
# Calling modules: Query
#
# Author: Capt Frank W. DeMarco
# History:
# 1.0 Frank W. DeMarco 8/1/85 - input original code

******************************************************************************

procedure RegStu;

var
  i, j : integer;

begin (* Procedure RegStu *)

  for j := 1 to 11 do
    npupil.studentnumber[j] := ' ';
  for j := 1 to 28 do
    npupil.studentname[j] := ' ';
  for j := 1 to MAXLESSONS do
    npupil.lessons[j] := ' ';
  for i := 1 to MAXLESSONS do
    begin
      for j := 1 to MAXTOPICS do
        npupil.topics[i,j] := ' ';
    end;

  writeln;
  writeln('Since this is your first time into this course, I have a few ');
  writeln('administrative matters to take care of. ');
  writeln;
  writeln('Please enter your first name: ');
  write('(Max. of 10 characters) >>>>> ');
  
  i := 1;
  while not (eoln) and (i < 11) do
    begin
      read (npupil.studentname[i]);
      i := i + 1
    end;
  if (eoln) and (i < 11) then
    begin
      for i := 1 to 10 do
        npupil.studentname[i] := '#';

B - 4
readln
end
else
  readln;
writeln;
writeln;
writeln('Please enter your middle initial: '); writeln('Max. of 1 character') >>

i := 11;
while not (eoln) and (i < 12) do
  begin
    read (npupil.studentname[i]);
    i := i + 1
  end;
if (npupil.studentname[11] in ['a'..'z','A'..'Z']) then
  begin
    npupil.studentname[12] := '.';
    readln
  end
else
  begin
    npupil.studentname[12] := '#';
    readln
  end;
writeln;
writeln;
writeln('Please enter your last name: '); writeln('Max. of 16 characters') >>

i := 13;
while not (eoln) and (i < 29) do
  begin
    read (npupil.studentname[i]);
    i := i + 1
  end;
if (eoln) and (i < 29) then
  begin
    for i := 1 to 28 do
      npupil.studentname[i] := '*';
    readln
  end
else
  readln;
writeln;
writeln;
writeln('Now for the most important part.'); writeln('Please enter your unique, personal student identification number: '); write('(Max. of 11 characters) >>>> '); n := 1;
while not (eoln) and (n < 12) do begin read (npupil.studentnumber[i]); n := n + 1 end;
if (eoln) and (n < 12) then begin for i := n to 11 do npupil.studentnumber[i] := '*'; readln
end else readln;
for i := 1 to MAXLESSONS do begin npupil.lessons[i] := '-';
for j := 1 to MAXTOPICS do npupil.topics[i,j] := '-';
end;
studentcount := studentcount + 1
end; (* Procedure RegStu *)

******************************************************************************
* Date: 8/1/85
* Version: 1.0
* Name: procedure Query
* Module number: 4.0
* Description: Reads in "STUDENT" file, prompts student for student identification number, and checks the ID number against current student list.
* Passed Variables: None
* Returns: None
* Global Variables Used: rpupil, studentcount, npupil
* Global Variables Changed: rpupil, studentcount, npupil
* Files Read: student
* Files Written: None
* Modules Called: Clear Screen, ReqStu
* Calling modules: program CAI
* Author: Capt Frank W. DeMarco
* History:
* 1.0 Frank W. DeMarco 8/1/85 - input original code
******************************************************************************
procedure Query;

var
  i, ii, j : integer;
  qfound : boolean;
  character : char;

begin (* Procedure Query *)
  assign (student, 'student');
  reset (student);
  character := '';
  if not (eof(student)) then
    read (student, character);
  for i := 1 to MAXSTUDENTS do
    begin
      for j := 1 to 11 do
        rpupil[i].studentnumber[j] := '';
      for j := 1 to 28 do
        rpupil[i].studentname[j] := '';
      for j := 1 to MAXLESSONS do
        rpupil[i].lessons[j] := '';
      for ii := 1 to MAXLESSONS do
        begin
          for j := 1 to MAXTOPICS do
            rpupil[i].topics[ii, j] := '';
        end;
    end;

  i := 1;
  studentcount := 0;
  while (character = '>') and not (eof(student)) do
    begin
      studentcount := studentcount + 1;
      while not (eoln(student)) do
        begin
          for j := 1 to 11 do
            read (student, rpupil[i].studentnumber[j]);
          for j := 1 to 28 do
            read (student, rpupil[i].studentname[j]);
          for j := 1 to MAXLESSONS do
            read (student, rpupil[i].lessons[j]);
          for ii := 1 to MAXLESSONS do
            begin
              for j := 1 to MAXTOPICS do
                read (student, ri[i].topics[ii, j])
            end;
          i := i + 1;
        end;
  end;
  if not (eof(student)) then
    readln (student);
if not (eof(student)) then
    read (student.character);
end;

ClearScreen;

write('Please enter your student identification number: ');
write('(Max. of 11 characters) >>>>> ');

i := 1;
while not (eoln) and (i < 12) do
    begin
        read (npupil.studentnumber[i]);
        i := i + 1
    end;
if (eoln) and (i < 12) then
    begin
        for i := 1 to 11 do
            npupil.studentnumber[i] := '*'
        end;
readln;

i := 1;
ofound := false;
while (i < 21) do
    begin
        if (npupil.studentnumber = rpupil[i].studentnumber) then
            begin
                ofound := true;
                npupil.studentname := rpupil[i].studentname;
                npupil.lessons := rpupil[i].lessons;
                for ii := 1 to MAXLESSONS do
                    begin
                        for j := 1 to MAXTOPICS do
                            npupil.topics[ii,j] := rpupil[i].topics[ii,j]
                    end;
                i := i + 1
            end;
        if not (ofound) and (studentcount < MAXSTUDENTS) then
            begin
                ClearScreen;
                writeln ('NO MATCH FOUND');
                RegStu;
                ClearScreen
            end
        else if not (ofound) and (studentcount = MAXSTUDENTS) then
            begin
                ClearScreen;
                studentcount := studentcount + 1;
                writeln('Sorry, but my class roster shows a "Full" class.');
            end;


writeln('Please see your training monitor for a new student disk.');
writeln;
writeln('END OF PROGRAM')
end;

close (student)

end;  (* Procedure Query *)

(*******************************************************************************
 * Date: 8/1/85
 * Version: 1.0
 * Name: procedure StartEnd
 * Module number: 3.0
 * Description: Reads and displays files "INTRO" at start of program and
 * "EXIT" at end of program.
 * Passed Variables: code
 * Returns: None
 * Global Variables Used: println, linecount, advance
 * Global Variables Changed: println, linecount, advance
 * Files Read: intro, exit
 * Files Written: None
 * Modules Called: ClearScreen
 * Calling modules: program CAI
 * Author: Capt Frank W. DeMarco
 * History:
 * 1.0 Frank W. DeMarco 8/1/85 - input original code
*******************************************************************************

procedure StartEnd(code : char);

var
  character : char;
  : : integer;

begin  (* Procedure StartEnd *)

  case code of
    'S' : assign (iomessage,'intro');
    'E' : assign (iomessage,'exit')
  end:

  reset (iomessage);
  read (iomessage,character);
  linecount := 0;

  repeat
    while (character = '#') and not (eof(iomessage)) do
      begin
        for i := 1 to 80 do


procedure Select;

var

lessonstat: integer;
println: text;
choice: char;

begin
    println[i] := ' ';
    readln (iomessage,println);
    linecount := linecount + 1;
    writeln (println);
    if not (eof(iomessage)) then
        read (iomessage,character)
    end;

    if (character = '!') then
    begin
        advance := 23 - linecount;
        linecount := 0;
        for i := 1 to advance do
            writeln;
        for i := 1 to 27 do
            write ('');
        write ('Press RETURN to continue.');
        readln;
        if not (eof(iomessage)) then
            begin
                readln(iomessage);
                if not (eof(iomessage)) then
                    read (iomessage, character)
            end;
        ClearScreen
    end;
    until (eof(iomessage));

    close (iomessage)
end:

(* Procedure StartEnd *)

*******************************************************************************
* Date: 9/1/85
* Version: 1.0
* *
* Name: procedure Select
* Module number: 5.0
* Description: Reads and displays file "MENU", prompts the student for
* choice of lesson to be shown.
* Passed Variables: None
* Returns: None
* Global Variables Used: lessonstat, println, choice
* Global Variables Changed: lessonstat, println, choice
* Files Read: menu
* Files Written: None
* Modules Called: ClearScreen
* Calling modules: program CAI
* *
* Author: Cast Frank W. DeMarco
* History: *
* 1.0 Frank W. DeMarco 9/1/85 - input original code
*******************************************************************************
procedure Select;

var
  character : char;
  i, j : integer;

begin (* Procedure Select *)

  assign (menu,'menu');

  for i := 1 to MAXLESSONS do
    lessonstat[i] := npupil.lessons[i];

  repeat
    reset (menu);
    read (menu,character);

    j := 0;
    while (character in ['*','@']) and not (eof(menu)) do
      begin
        readln (menu,println);

        if (character = '*') then
          begin
            write ('*');
            for i := 2 to 78 do
              write (printin[i]);
            writeln (printin[79]);
          end
        else
          begin
            j := j + 1;
            write ('*');
            for i := 2 to 8 do
              write (printin[i]);
            write (lessonstat[j]);
            for i := 10 to 78 do
              write (printin[i]);
            writeln (printin[79]);
          end;

        if not (eof(menu)) then
          read (menu,character)
      end;

  writeln;
  write ('ENTER THE NUMBER OF YOUR CHOICE OR "X" TO EXIT THE CAI PROGRAM: ') ;
  readln (choice);
  if ('choice in ['1','LESSON,'X','X']') then
    ClearScreen
  else
begin
  ClearScreen:
  writeln ('Sorry, ',choice,' is not a valid response. Please try again.')
end;

until (choice in ['1'..VLESSON,'x','X']);

if (choice in ['1'..VLESSON]) then
  writeln ('You have chosen lesson number ',choice,'. Thank you.')
else
  writeln ('OK, I will now return you to the operating system.');
end (menu)
close (menu)
end:  {* Procedure Select *}

(*---------------------------------------------------------------
*        Date: 8/1/95
*        Version: 1.0
*        Name: procedure ShowTopic
*        Module number: 6.1
*        Description: Driver of procedures that display topic material.
*        Passed Variables: None
*        Returns: None
*        Global Variables Used: lessonIn, npupil, topicstat
*        Global Variables Changed: npupil, topicstat
*        Files Read: None
*        Files Written: None
*        Modules Called: ClearScreen, BlankLines, ReadLines, StorePositions,
*                         Tframe, Oframe
*        Calling modules: StartLesson
*        Author: Capt Frank W. DeMarco
*        History:
*          1.0 Frank W. DeMarco 8/1/95 - input original code
*---------------------------------------------------------------*)

procedure ShowTopic:

const
  MINSCORE = 70.0;

type
  position = record
      framenum : integer;
      value : integer;
    end;

  to dici letitle = packed array [1..30] of char;

var
  lplace : array [1..50] of position;
tname : topictitle;
procedure BlankLines:

var index1, index2 : integer;
begin (* Procedure BlankLines *)
  for index1 := 1 to 500 do
    begin
      for index2 := 1 to 80 do
        lessonln[index1,index2] := ' ';
    end;

  for index1 := 1 to 70 do
    tname[index1] := ' ';

  for index1 := 1 to 50 do
    begin
      lplace[index1].framenum := 0;
      lplace[index1].value := 0;
    end;
end; (* Procedure BlankLines *)

*****************************************************************************
procedure ReadLines;

var
  rfouFnd: boolean;
  ivalue, iValue: integer;

begin (* Procedure ReadLines *)

  writeln;
  writeln ('One moment please...');

  rfouFnd := false;
  reset (lesson);

  repeat
    read (lesson, lessonIn[1,1]);
    if (lessonIn[1,1] = lchoice) then
      rfouFnd := true
    else
      readln (lesson);
  until (rfouFnd);

  i := 2;
  while not (eoln(lesson)) do
  begin
    readln (lesson, lessonIn[1,i]);
    i := i + 1
  end;

  readln (lesson);
  i := 2;
  readln (lesson, lessonIn[1,i]);

  i := 2;

while (lessonL[i, j] = 1choice) and not (eof (lesson)) do
begin
  while not (eoln (lesson)) do
  begin
    read (lesson, lessonL[i, j]);
    j := j + 1
  end;
  readln (lesson);
  i := i + 1;
  j := 1;
  if not (eof (lesson)) then
    read (lesson, lessonL[i, j]);
    j := j + 1
  end;

  ivalue := i;
  for ivalue := 16 to 45 do
  begin
    tname[ivalue] := lessonL[i, jvalue];
    ivalue := ivalue + 1;
  end;
end;

(* Procedure ReadLines *)

(*----------------------------------------------------------*
 * Date: 9/1/95                                          *
 * Version: 1.0                                          *
 * Name: procedure StorePositions                        *
 * Module number: 6.1.3                                   *
 * Description: Builds an array of line positions where frames begin within the topic. *
 * Passed Variables: None                                *
 * Returns: None                                         *
 * Global Variables Used: lessonL, i, j, k, lplace, lchoice *
 * Global Variables Changed: i, j, k, lplace              *
 * Files Read: None                                      *
 * Files Written: None                                   *
 * Modules Called: None                                  *
 * Calling modules: ShowTopic                            *
 * Author: Capt Frank W. DeMarco                          *
 * History:                                              *
 * 1.0 Frank W. DeMarco 9/1/95 - input original code      *
 *----------------------------------------------------------*)

procedure StorePositions;
var
  *number, jvalue : integer;
begin (* Procedure StorePositions *)
i := 1;
j := 2;
k := 0;

repeat
  if (lessonln[i, j] = '1') then
    begin
      k := k + 1;
      fnumber := 0;
      for jval := 9 to 11 do
        begin
          fnumber := (10 * fnumber) + ((ord(lessonln[i, jval])) - ord('0'));
          lplace[k].framenum := fnumber;
          lplace[k].ivalue := i;
          i := i + 1
        end
      else
        i := i + 1;
    until (lessonln[i, 1] <> 1choice);
  k := k + 1; /* This marks the end */
  lplace[k].framenum := -1; /* of the array */
end; /* Procedure StorePositions */

*******************************************************************************
* Date: 8/1/95
* Version: 1.0
* Name: procedure FrameHeader
* Module number: 7.0
* Description: Displays a frame header for a frame.
* Passed Variables: None
* Returns: None
* Global Variables Used: None
* Global Variables Changed: None
* Files Read: None
* Files Written: None
* Modules Called: ClearScreen
* Calling modules: Tframe, Muestion, Muestion
* Author: Capt Frank W. DeMarco
* History:
* 1.0 Frank W. DeMarco 8/1/95 - input original code
*******************************************************************************

procedure FrameHeader;
begin  /* Procedure FrameHeader */
  ClearScreen;
  writeln (ALINEFL,ALINEFR):
procedure Tframe(istart : integer);

var
    jnum : integer;

begin (* Procedure Tframe *)

  advance := 0;
  linecount := 0;
  istart := istart + 1;

  FrameHeader;
  writeln (A.BLANKS, BLANKSA);

  repeat
      while (lessonln[istart,2] = 'C' and linecount < 17) do begin
      write ('* ');
          for jnum := 2 to 78 do write (lessonln[istart, jnum]);
      writeln ('* ');
      istart := istart + 1;
      linecount := linecount + 1;
      end;
  writeln (A.BLANKS, BLANKSA);
  advance := 27 - (linecount + 5);
end;
for i := 1 to (advance - 1) do
  writeln (ABLANKS, BLANKSA);
  writeln (ALINEP1, ALINEP2);
for i := 1 to 27 do
  write ('Press RETURN to continue.');
readln;
linecount := 0;
if lessonIn[istart, 2] = '2' then
  begin
    FrameHeader:
    writeln (ABLANKS, BLANKSA)
  end;
until (lessonIn[istart, 2] = '3');
if (lessonIn[istart, 2] = '3') then
  begin
    if (lessonIn[istart, 3] = 'B') then
      begin
        nextframe := 0;
        for i := 5 to 7 do
          nextframe := (10 * nextframe) +
            (ord(lessonIn[istart, i]) - ord('0'))
      end
    else
      nextframe := -1;
  end;
end; (* Procedure Tframe *)

******************************************************************************
* Date: 9/1/85
* Version: 1.0
* Name: procedure Tframe
* Module number: 6.1.5
* Description: Driver for the procedures that display and handle question
  type frames.
* Passed Variables: istart
* Returns: None
* Global Variables Used: lessonIn
* Global Variables Changed: None
* Files Read: None
* Files Written: None
* Modules Called: ClearScreen, Mquestion, Pquestion
* Calling modules: ShowTopic
* Author: Cact Frank W. DeMarco
* History:
  * 1.0 Frank W. DeMarco 9/1/85 - input original code
******************************************************************************

procedure Tframe(istart : integer);
procedure Mquestion(istart : integer);

var
    jnum : integer;
    response, correct, groupnum : char;
    notfound : boolean;

begin (* Procedure Mquestion *)

    istart := istart + 1;

    FrameHeader;

    writeln;
    writeln;

    while (lessonIn[istart,2] = '2') do
    begin
      for jnum := 7 to 80 do
        write (lessonIn[istart,jnum]);
      writeln;
      istart := istart + 1
    end;

    writeln;

    while (lessonIn[istart,2] = '7') do
if (lessonln[istart,4] = '+') then
    correct := lessonln[istart,3];
write (' ', lessonln[istart,3], ', ');
for jnum := 6 to 80 do
    write (lessonln[istart, jnum]);
writeln;
    istart := istart + 1
end;

repeat
    writeln;
    write (' Enter your choice here ==> ');
    readln (response);
    if (response in ['A','E','a','e']) then
        writeln
    else
        writeln (' Sorry, that is not a valid response. Please try again.');
until (response in ['A','E','a','e']);

case response of
    'A','E': response := 'A';
    'B','E': response := 'B';
    'C','C': response := 'C';
    'D','D': response := 'D';
    'E','E': response := 'E'
end;

writeln (templ.choice,choice,frame:3,correct,response);

if (response = correct) then
    begin
        if (test) then
            numright := numright + 1.0;
            groupnum := '4'
        end
    else
        groupnum := '5';
    mfound := false;
repeat
    if (lessonln[istart,2] = groupnum) then
        mfound := true
    else
        istart := istart + 1;
    until (mfound);
if (groupnum = '4') then /* Start Group '4' Logic */
begin
    while (lessonln[istart,4] <> 'B') or (lessonln[istart,5] <> 'I') do
        begin
            for jnum := 4 to 80 do
                write (lessonln[istart, jnum]);
writeln;
istart := istart + 1
end;
if (lessonln[istart,4] = 'B') and (lessonln[istart,5] = ':') then
begin
nextframe := 0;
for jnum := 6 to 8 do
nextframe := (10 * nextframe) +
(ord(lessonln[istart,jnum]) - ord('0'))
end
else
nextframe := -1
end: (* End Group '4' Logic *)

if (groupnum = '5') then (* Start Group '5' Logic *)
begin
if (lessonln[istart,3] = response) and
(lessonln[istart,4] = ':') then
begin
while (lessonln[istart,4] <> 'B') or
(lessonln[istart,5] <> ':') do
begin
for jnum := 5 to 80 do
write (lessonln[istart,jnum]);
writeln;
istart := istart + 1
end;
end
else
begin
mfound := false;
jnum := 3;
repeat
while (lessonln[istart,jnum] <> ':') and not (mfound) do
begin
if (lessonln[istart,jnum] = response) then
mfound := true;
jnum := jnum + 1
end;
if not (mfound) then
begin
istart := istart + 1;
jnum := 3
end
else
begin
while (lessonln[istart,jnum] <> ':') do
jnum := jnum + 1
end;
until (mfound) or (lessonln[istart,2] <> '5');
if (mfound) then
begin

end

end; (* End Group '5' Logic *)
while (lessonln[istart,4] <> 'B') or (lessonln[istart,5] <> ':') do
begin
  for jnum := jnum to 80 do
    writeln:
      jnum := 4;
  istart := istart + 1
end;
if (lessonln[istart,4] = 'B') and (lessonln[istart,5] = ':') then
begin
  nextframe := 0;
  for ,num := 5 to 9 do
    nextframe := (10 * nextframe) + (
      (ord(lessonln[istart,jnum]) - ord('0'))
    )
end
else
  nextframe := -1
else
  writeln ('SOMETHING IS AWRY! LET'S TRY THAT AGAIN."
end:
end:
(* Procedure Mquestion *)

******************************************************************************

* Date: 9/1/95
* Version: 1.0
*
* Name: procedure Puestion
* Module number: 5.1.2
* Description: Displays and handles pick type question frames (true/false
* and yes/no).
* Passed Variables: istart
* Returns: None
* Global Variables Used: lessonln, choice, lchoice, frame, test, numright,
* nextframe
* Global Variables Changed: numright, nextframe
* Files Read: None
* Files Written: temp!
* Modules Called: FrameHeader
* Calling modules: Oframe
*
* Author: Capt Frank W. DeMarco
* History:
* 1.0 Frank W. DeMarco 9/1/95 - input original code
******************************************************************************

procedure Puestion(istart : integer);
type
  responses = packed array [1..5] of char:

B - 22
var
    jnum, index : integer;
    answer : responses;
    correct, response, groupnum : char;
    pfound, ptrue : boolean;

begin (* Procedure Pquestion *)

    istart := istart + 1;
    FrameHeader;
    writeln;

    while (lessonln[istart,2] = '2') do
    begin
        for jnum := 3 to 80 do
            write (lessonln[istart,jnum]);
        writeln;
        istart := istart + 1
    end;
    writeln;

    if (lessonln[istart,2] = '3') then
    begin
        correct := lessonln[istart,3];
        istart := istart + 1
    end;

repeat
    index := 1;
    writeln ('Enter your choice here ==> ');
    while not (eoln) and (index < 6) do
    begin
        read (answer[index]);
        index := index + 1
    end;
    if (eoln) and (i < 5) then
    begin
        for index := index to 5 do
            answer[index] := ' ';
        readln;
    end else
        readln;
    ptrue := false;

    if ('answer[1] in ['t','T','f','F','y','Y','n','N']) then
        ptrue := true
    else
        writeln ('Sorry, that is not a valid response. Please try again. ');
until (ptrue);
case answer[1] of
  't', 'T', 'y', 'Y' : response := 'Y';
  'f', 'F', 'n', 'N' : response := 'N'
end;

writeln (temp1,choice,1choice,frame:3,correct,response);

if (response = correct) then
  begin
    if (test) then
      numright := numright + 1.0;
      groupnum := '4'
    else
      groupnum := '5';
  end
else
  groupnum := '0';
pfound := false;

repeat
  if (lessonIn[istart,2] = groupnum) then
    pfound := true
  else
    istart := istart + 1;
until (pfound);

while (lessonIn[istart,4] <> 'B') or (lessonIn[istart,5] <> ':') do
  begin
    writeln;
    for jnum := 4 to 90 do
      write (lessonIn[istart,jnum]);
    istart := istart + 1
  end;

if (lessonIn[istart,4] = 'B') and (lessonIn[istart,5] = ':') then
  begin
    nextframe := 0;
    for jnum := 6 to 9 do
      nextframe := ((10 * nextframe) +
                     ((ord(lessonIn[istart,jnum]) - ord('O')))"
  end
else
  nextframe := -1
end;  (* Procedure Fquestion *)

(******************************************************************************
(* Start of main part of procedure: Oframe   *)
(******************************************************************************

begin  (* Procedure Oframe *)

if (lessonIn[istart,14] = 'M') then
  stype := 'M'

else
  qtype := 'P';

case qtype of
  'M' : Mquestion(istart);
  'P' : Pquestion(istart)
end:

writeln;
for iValo := 1 to 27 do
  write ('');
write ('Press RETURN to continue.');
readln;
end: (* Procedure Oframe *)

(*--------------------------------------------------*)
(* Start of main part of procedure: ShowTopic *)
(*--------------------------------------------------*)

begin (* Procedure ShowTopic *)

BlankLines;
ReadLines;
StorePositions;

numasked := 0.0;
numright := 0.0;
score := 0.0;
test := false;

if start := i1:
frame := 0;
for j := 9 to 11 do
  frame := (10 * frame) + ((ord(lessonln[istart, j])) - ord('0'));
if (lessonln[istart, 13] = 'T') and (lessonln[istart, 14] = 'T') then
  test := true;
repeat
  if (lessonln[istart, 2] = 'I') then
    begin
    ftype := lessonln[istart, 13];
    if (test) and (ftype = '0') then
      numasked := numasked + 1.0;
    case ftype of
      'T' : Tframe(istart);
      '0' : Oframe(istart)
    end:
  end;
  k := 0;
sfound := false;
repeat
  k := k + 1;
  if (lplace[k].framenum = nextframe) then
  begin
    istart := lplace[k].i.value;
    frame := lplace[k].framenum;
    sfound := true
  end;
  until (sfound) or (lplace[k].framenum = -1);
end;

until not (sfound) or (lplace[k].framenum = -1);

i := ord(choice) - ord('0');
j := ord(lchaoice) - ord('0');

if (test) then
  begin
    ClearScreen;
    score := numright/numasked;
    score := (score * 100.0);
    writeln ('Your test score = ',score:1:2,
    writeln;
    if (score >= MINSCORE) then
      begin
      writeln ('CONGRATULATIONS! YOU HAVE PASSED THE LESSON TEST.');
      npupil.topics[i,j] := '+';
      npupil.lessons[i] := '+';
      topicstat[j] := '+'
      end
    else
      begin
      writeln ('Sorry, but you missed too many questions to pass the test.');
      writeln;
      write ('I suggest that you review at least one topic before you ');
      writeln ('retake the lesson test.');
      npupil.topics[i,j] := '-';
      npupil.lessons[i] := '-';
      topicstat[j] := '-'
      end
    end
  else
  begin
    ClearScreen;
    npupil.topics[i,j] := '+';
    topicstat[j] := '+'
  end;
end: (* Procedure ShowTopic *)
procedure RecordStats;

var
  i : integer;

begin (* Procedure RecordStats *)

  writeln;
  writeln ('One moment please, while I update my records.');
  assign (temp2,'t2');
  assign (statfile,'stats');
  reset (temp1);
  rewrite (temp2);
  reset (statfile);

repeat
  while not (eof(statfile)) do
    begin
      for i := 1 to 80 do
        println[i] := '';
      readln (statfile,println);
      writeln (temp2,println);
    end;
  until (eof(statfile));
repeat
  while not (eof(temp1)) do
    begin
      for i := 1 to 80 do
        println[i] := '';
      readln (temp1,println);
      writeln (temp2,println);
    end;
  until (eof(temp1));
reset (temp2);
rewrite (statfile);

repeat
  while not (eof(temp2)) do
    begin
      for i := 1 to 80 do
        println[i] := ";
        readln (temp2,println);
        writeln (statfile,println)
    end;
  until (eof(temp2));

rewrite (temp1);
rewrite (temp2);
close (temp1);
close (temp2);
close (statfile);
end;

(* Procedure RecordStats *)

*******************************************************************************/
* Date: 9/1/85
* Version: 1.0
* *
* Name: procedure StuRec
* Module number: 6.3
* Description: Writes updated student course progress data to file
* "STUDENT".
* *
* Passed Variables: None
* Returns: None
* Global Variables Used: studentcount, npupil, npupil
* Global Variables Changed: none
* Files Read: None
* Files Written: student
* Modules Called: None
* Calling modules: StartLesson
* *
* Author: Capt Frank W. DeMarco
* History:
* 1.0 Frank W. DeMarco 8/1/85 - input original code
*******************************************************************************/

procedure StuRec;

var
  i, ii, j: integer;

begin (* Procedure StuRec *)

rewrite ('student');
for i := 1 to studentcount do
  if (rpupil[i].studentnumber <> npupil.studentnumber) and
     (rpupil[i].studentnumber <> '') then
    begin
      write(student, '>
      for j := 1 to 11 do
        write(student, rpupil[i].studentnumber[j]);
      for j := 1 to 28 do
        write(student, rpupil[i].studentname[j]);
      for j := 1 to MAXLESSONS do
        write(student, rpupil[i].lessons[j]);
      for ii := 1 to MAXLESSONS do
        begin
          if (ii < MAXLESSONS) then
            for j := 1 to MAXTOPICS do
              write (student, rpupil[i].topics[ii, j])
          else
            begin
              for j := 1 to (MAXTOPICS-1) do
                write (student, rpupil[i].topics[ii, j]);
              writeln (student, rpupil[i].topics[ii, MAXTOPICS])
            end;
        end;
      end;
      write(student, '>
      for i := 1 to 11 do
        write(student, npupil.studentnumber[i]);
      for i := 1 to 29 do
        write(student, npupil.studentname[i]);
      for i := 1 to MAXLESSONS do
        write(student, npupil.lessons[i]);
      for i := 1 to MAXLESSONS do
        begin
          for j := 1 to MAXTOPICS do
            write (student, npupil.topics[i, j])
        end;
    end;
  end;
end; (* Procedure StuRec *)

(* Procedure StuRec *)

Date: 8/1/85
Version: 1.0

Name: procedure StartLesson
Module number: 6.0
Description: Displays topic choices for a lesson, prompts student for
choice of topic to be shown. Driver of procedures that display lesson material and update statistical & student
progress files.
Passed Variables: None

B - 29
procedure StartLesson:

var
  i, j, k, index : integer;
  character : char;

begin (* Procedure StartLesson *)

  case choice of
    '1' : assign (lesson,'b:lesson1');
    '2' : assign (lesson,'b:lesson2');
    '3' : assign (lesson,'b:lesson3');
    '4' : assign (lesson,'b:lesson4');
    '5' : assign (lesson,'b:lesson5');
    '6' : assign (lesson,'b:lesson6');
  end;

  index := ord(choice) - ord('0');
  for i := 1 to MAXTOPICS do
    topicstat[i] := npupil.topics[index,i];

  reset (lesson);
  read (lesson.character);
  linecount := 0;

  repeat
    while (character = '#') and (linecount < 23) do
      begin
        for i := 1 to 80 do
          println[i] := ' ';
        readln (lesson,println);
        linecount := linecount + 1;
        writeln (println);
        read (lesson.character)
      end;

  end:

end.

if (character = '!') then
    begin
    advance := 23 - linecount;
    linecount := 0;
    for i := 1 to advance do
        writeln;
    for i := 1 to 27 do
        write ('');
    write ('Press RETURN to continue.');
    readln;
    readln (lesson);
    read (lesson,character);
    ClearScreen
    end;

    until not (character in ['#','!'])

    for i := 1 to 22 do
    begin
    for j := 1 to 80 do
        menuin[i,j] := ' '
    end:

    menuin[1,1] := character;
    for j := 2 to 79 do
        read (lesson,menuin[1,j]);
    readln (lesson,menuin[1,80]);

    for i := 2 to 22 do
    begin
    for j := 1 to 79 do
        read (lesson,menuin[i,j]);
    readln (lesson,menuin[i,80])
    end;

    repeat
    assign (temp1,'t1');
    rewrite (temp1);
    repeat
    k := 0;
    i := 1;
    while (menuin[1,1] in ['*','@']) do
    begin
    if (menuin[1,1] = '*') then
    begin
    for j := 1 to 79 do
        write (menuin[i,j]);
    writeln (menuin[1,80])
    end
    else
    begin
    i := k + 1;
    write ('*');
for j := 2 to 8 do
  write (menuIn[i,j]);
write (topicStat[j]);
for j := 10 to 79 do
  write (menuIn[i,j]);
writeln (menuIn[i,80])
end;
i := i + 1
end;

writeln;
write ('ENTER THE TOPIC NUMBER OF YOUR CHOICE OR "X" TO EXIT THIS LESSON: ');
readln (choice);
if (choice in ['1'..VTOPIc,'x','X']) then
  ClearScreen
else
  begin
    ClearScreen;
    writeln ('Sorry, ',choice, ' is not a valid response. Please try again.')
  end;
until (choice in ['1'..VTOPIc,'x','X']);

if (choice in ['1'..VTOPIc]) then
  writeln ('You have chosen topic number ',choice, '. Thank you.')
else
  writeln ('OK, I will now return you to the lesson selection menu.');

if (choice in ['1'..VTOPIc]) then
  begin
    ShowTopic;
    RecordStats;
    StuRec;
    ClearScreen
  end;
until (choice in ['x','X']);
close (temp1);
close (lesson)
end;  (* Procedure StartLesson *)

(*----------------------------------*)
(* Start of main driver: Program CAI *)
(*----------------------------------*)

begin (* Program CAI *)

ClearScreen;
StartEnd('S');
Query:

B - 32
if (studentcount \leq MAXSTUDENTS) then
begin
repeat
begin
Select;
if (choice in ['1'..'VLESSON']) then
StartLesson
end
until (choice in ['x','X']);
StartEnd('E')
end
end. (* Program CAI *)
Program "STUDENT_STATUS"

(**** THIS PROGRAM WAS WRITTEN IN PARTIAL FULFILLMENT OF A MASTERS THESIS ****)

* Date: 9/1/85
* Version: 1.0

* Title: Program Student_Status
* Filename: STATUS.PAS
* Coordinator: Capt Frank W. DeMarco
* Project: Masters Thesis
* Operating System: MS-DOS
* Language: Pascal

* User Compile and link with PASCAL.LIB using MS-Pascal compiler and linker.

* Contents: Program Student_Status - Main Driver.
  Procedure ClearScreen - Clears Z-100 terminal screen.
  Procedure QueryUser - Determines the users preferred method of program output (screen or hardcopy).
  Procedure Header - Produces the program report header.
  Procedure Display - Produces the status report for all students in file "STUDENTS".
  Procedure EndScreen - Completes the screen display format for the screen method of program output.

* Function: The purpose of this program is to provide a means for training managers, as well as personnel of the CAI Plans Branch (3300 TCHTW at Heather AFB, to check student progress in the CAI course.

(******************************************************************************)

* Date: 9/1/85
* Version: 1.0

* Name: program Student_Status
* Module number: 1.0
* Description: Main driver of program
* Passed Variables: None
* Returns: None
* Global Variables Used: studentcount, character, advance, choice
* Global Variables Changed: studentcount, character, advance
* File Read: student
* Files Written: None
* Modules Called: ClearScreen, QueryUser, Header, Display, EndScreen
* Calling modules: None
* Author: Capt Frank W. DeMarco
* History:
  1.0 Frank W. DeMarco 9/1/85 - input original code

******************************************************************************)
program Student_Status (input, output);

const
ALINEP1 = '***********************************';
ALINEP2 = '***********************************';
ADASH = '--------------------------------------';
DASHA = '--------------------------------------';
NUMLESSONS = 6;
NUMTOPICS = 30;

type
iofile = TEXT;

var
infile : iofile;

choice, character : char;
advance, 1, studentcount : integer;

procedure ClearScreen;
begin (* Procedure ClearScreen *)
write (chr(27), 'H', chr(27), 'J', chr(27), 'w')
end; (* Procedure ClearScreen *)
Module number: 1.2

Description: Determines the user's preferred method of program output (screen or hardcopy).

Passed Variables: choice

Returns: choice

Global Variables Used: None

Global Variables Changed: None

Files Read: None

Files Written: None

Modules Called: None

Calling modules: program Student Status

Author: Cast Frank W. DeMarco

History:

1.0 Frank W. DeMarco 9/1/85 - input original code

********************************************************************************

procedure QueryUser(var choice: char);

begin (* Procedure QueryUser *)

  write ('The output of this program can be put into two (2) different formats.');
  writeln ('formate.');
  writeln ('If you plan on getting a hard copy; type H .');
  writeln ('If you only want a screen display; type S .');

  repeat
    writeln;
    write ('Enter your choice here == > ');
    readln (choice);
    until (choice in ['H','H','s','S']);

  if (choice in ['H','H']) then
    begin
      writeln;
      writeln ('Press <P (CONTROL P) and then RETURN to get printout');
      readln
    end

end: (* Procedure QueryUser *)

********************************************************************************
procedure Display(var character: char;
    var studentcount: integer);

unit
  roll = record
studentnumber : packed array [1..11] of char;
studentname : packed array [1..29] of char;
lessons : packed array [1..NUMLESSONS] of char;
topics : packed array [1..NUMTOPICS] of char;
end;

var
pupil : roll;

begin (* Procedure Display *)
studentcount := studentcount + 1;
while not (eof(infile)) do
begin
  for i := 1 to 11 do
    read (infile,pupil.studentnumber[i]);
  for i := 1 to 29 do
    read (infile,pupil.studentname[i]);
  for i := 1 to NUMLESSONS do
    read (infile,pupil.lessons[i]);
  for i := 1 to NUMTOPICS do
    read (infile,pupil.topics[i]);
end;
write ('*');
for i := 1 to 11 do
begin
  if (pupil.studentnumber[i] = '*') then
    write ('*')
  else
    write (pupil.studentnumber[i])
end;
write ('**');
for i := 1 to NUMLESSONS do
begin
  if (pupil.lessons[i] = '*') then
    write ('* Passed ')
  else
    begin
      if (i < NUMLESSONS) then
        write ('* ')
      else
        write ('* ')
    end;
  if (i < NUMLESSONS) then
    write ('** ')
  else
    writeln ('**');
end;
if not (eof(infile)) then
  readln (infile);
if not (eof(infile)) then
  read (infile, character);
end; (* Procedure Display *)

(*-------------------------------*
 Date: 9/1/85
 Version: 1.0

 Name: procedure EndScreen
 Module number: 1.5
 Description: Completes the screen display format for the screen method of
 program output.
 Passed Variables: advance
 Returns: None
 Global Variables Used: None
 Global Variables Changed: None
 Files Read: None
 Files Written: None
 Modules Called: ClearScreen
 Calling modules: program Student_Status

 Author: Capt Frank W. DeMarco
 History:
  1.0 Frank W. DeMarco 9/1/85 - input original code

************************************************************************************************************)

procedure EndScreen(advance: integer);
begin (* Procedure EndScreen *)
  for i := 1 to (advance - 1) do begin
    write ('*    
           *    
           *    
           *    
           *    
           *    
     end;
  writeln (ALINER1, ALINER2);
  for i := 1 to 24 do write (" ");
  if not (eof(infile)) then begin
    write ('Press RETURN to continue.');
    readin;
    ClearScreen;
  end else begin
    write ('Press RETURN to end program.');
    readin
  end
end; (* Procedure EndScreen *)
begin (* Program Student_Status *)

ClearScreen;
QueryUser(choice);
ClearScreen;
Header;
assign (infile,'student');
reset (infile);
read (infile,character);

repeat
  studentcount := 0;
  while (character = '>') and (studentcount < 16) and not (eof(infile)) do
    Display(character,studentcount);
    advance := $I - (studentcount + 6);
    if (choice in ['s','S']) then
      EndScreen(advance);
    until (eof(infile));

  if (choice in ['s','S']) then
    ClearScreen
  else
    writeln (ALINEP1,ALINEP2)

end. (* Program Student_Status *)
Program "CAI_STATISTICS"

(**** THIS PROGRAM WAS WRITTEN IN PARTIAL FULFILLMENT OF A MASTERS THESIS ****)

Date: 10/15/95
Version: 1.0

Title: Program CAI_Statistics
Filename: VALIDATE.PAS
Coordinator: Prof Frank W. DeMarco
Project: Masters Thesis
Operating System: MS-DOS
Language: Pascal

Use: Compile and link with PASCAL.LIB using MS-Pascal compiler and linker.

Contents: PROGRAM CAI_Statistics - Main Driver
  Procedure ClearScreen - Clears Z-100 terminal screen.
  Procedure QueryUser - Determines the users preferred method of
    program output (screen or hardcopy).
  Procedure Header - Produces the program report header.
  Procedure Init - Initializes array and two link lists used in
    the program as well as opening file "STATS".
  Procedure ReadStats - Reads file "STATS" into a linked list of
    frame records as well as builds an array
    of unique frame identifiers.
  Procedure Sort - Sorts the frame identifier array into numeric
    order.
  Procedure Display - Driver for the procedures that display the
    statistics for each unique question frame.
  Procedure FinalScreen - Wraps up the screen display after all
    statistics have been processed.
  Procedure BuildFrameLL - Constructs a linked list of frame re-
    cords that are of the same frame.
  Procedure InitDisplay - Initialization variables used in statistical
    analysis.
  Procedure ShowStats - Analyzes and displays statistical data
    stored in the linked list of frame records
    (of the same frame).
  Procedure EndScreen - Wraps up the screen display after there
    has been a full screen displayed.

Function: The purpose of this program is to provide a means for the OPR
  at Keeler AFB, to validate course material and teaching effec-
  tiveness by analyzing questions asked during lesson and test
  course presentation.

(***********************************************************************)

Date: 10/15/95
Version: 1.0

Name: program CAI_Statistics
Module number: 1.0
program CAL_Statistics (input, output);

const
ALINEP1 = '********************';
ALINEP2 = '********************';
ADASH = '------------------------';
DASHA = '------------------------';
Y_LESSEONS = 'y';

type
iofile = TEXT;
statistics = record
  ltframe_num : integer4;
  c_answer : char;
  e_response : char;
end;
stats_array = array [1..150] of integer4;
frameclone = ^framerate;
framerate = record
  ltf_num : integer4;
  c_ans : char;
  e_ans : char;
  next : frameclone
end;

var
infilen : iofile;
stats : stats_array;
tempbuff : statistics;
filehead, framehead, node, filenode, framenode : frameclone;
character, choice : char;
advance, linecount, dindx, tot_r, tot_w : integer;
num_A, num_B, num_C, num_D, num_E, num_Y, num_N : integer;
num_sen, num_right, num_wrong, percent_right, percent_wrong : real;
procedure ClearScreen:

begin (* Procedure ClearScreen *)

  write (chr(27), 'H', chr(27), 'J', chr(27), 'w');

end; (* Procedure ClearScreen *)

******************************************************************************

** Date: 10/15/85  
** Version: 1.0  
**  
** Name: QueryUser  
** Module number: 1.2  
** Description: Determines the users preferred method of program output  
**               (screen or hardcopy).  
** Passed Variables: choice  
** Returns: choice  
** Global Variables Used: None  
** Global Variables Changed: None  
** Files Read: None  
** Files Written: None  
** Modules Called: None  
** Calling modules: program CAI_Statistics  
**  
** Author: Capt Frank W. DeMarco  
** History:  
** 1.0 Frank W. DeMarco 10/15/85 - input original code  
*******************************************************************************
procedure QueryUser(var choice: char);
begin (* Procedure QueryUser *)
  write ('The output of this program can be put into two (2) different');
  writeln (' formats.');
  writeln ('If you plan on getting a hard copy; type H .');
  writeln ('If you only want a screen display; type S .');
  repeat
    writeln;
    write ('Enter your choice here == > ');
    readln (choice);
  until 'choice in [h', 'H', ', s', 'S']);
  if (choice in ['h', 'H']) then
    begin
      writeln;
      writeln ('Press <F (CONTROL F) and then RETURN to get printout');
      readln
    end;
end; (* Procedure QueryUser *)

(* ************************************************* *)
(* Date: 10/15/85                                      *)
(* Version: 1.0                                       *)
(* Name: Header                                       *)
(* Module number: 1.3                                  *)
(* Description: Produces the program report header.   *)
(* Passed Variables: None                             *)
(* Returns: None                                      *)
(* Global Variables Used: None                        *)
(* Global Variables Changed: None                     *)
(* Files Read: None                                   *)
(* Files Written: None                               *)
(* Modules Called: None                              *)
(* Calling modules: program CAI_Statistics, EndScreen *)
(* Author: Cast Frank W. DeMarco                     *)
(* History:                                           *)
(* 1.0 Frank W. DeMarco 10/15/85 - input original code *)
(* ************************************************* *)

procedure Header;
begin (* Procedure Header *)
  writeln ('ALINEF1,ALINEF2');
  writeln ('THE FOLLOWING IS A STATISTICAL VALIDATION REPORT FOR THE C1');
  writeln ('CAI COURSE. ');
end;
writeln (ALINEP1,ALINEP2);
write ('* L # : F # : # A # B : # C : # D : # E : # Y : # N *');
writeln ('* R : # W : % R : % W *');
writeln (ADASH,DASHA)
end; (* Procedure Header *)

(* *******************************************************)
* Date: 10/15/85
* Version: 1.0
*
* Name: Init
* Module number: 1.4
* Description: Initializes array and two link lists used in the program as
* well as opening file "STATS".
* Passed Variables: None
* Returns: None
* Global Variables Used: stats, filehead, filenode, node, framehead,
* frameode, character
* Global Variables Changed: stats, filehead, filenode, framehead, framenode
* character
* Files Read: stats
* Files Written: None
* Modules Called: None
* Calling modules: program CAI_Statistics
* Author: Capt Frank W. DeMarco
* History:
* 1.0 Frank W. DeMarco 10/15/85 - input original code
(* *******************************************************)

procedure Init;

var
  i : integer;

begin (* Procedure Init *)
  for i := 1 to 150 do
    stats[i] := 0;

  filehead := nil;
  new (node);
  filenode := node;
  filehead := filenode;

  framehead := nil;
  new (node);
  framenode := node;
  framehead := framenode;

  assign (infile,'stats');
  reset (infile);
  read (infile,character);
end; (* Procedure Init *)
procedure ReadStats;

var
  i : integer;
  fnumber : integer4;
  inchar : char;
  found : boolean;

begin (* Procedure ReadStats *)

  fnumber := 0;
  fnumber := (10 * fnumber) + (ord(character)) - ord('0'));
  for i := 1 to 4 do
    begin
      read (infile,inchar);
      fnumber := (10 * fnumber) + (ord(inchar)) - ord('0'))
    end;

  tempbuff.lframe_num := fnumber;
  read (infile,tempbuff.c_answer);
  read (infile,tempbuff.v_response);
  i := 1;
  found := false;
  while (stats[i] <> 0) do
    begin
      if (stats[i] = tempbuff.lframe_num) then
        found := true;
      i := i+1
    end;

end;
if not (found) then
    stats[i] := tempbuff.ltframe_num;
new (node);
    filenode-.next := node;
    filenode := node;
filenode-.ltf_num := tempbuff.ltframe_num;
    filenode-.c_ans := tempbuff.c_answer;
    filenode-.s_ans := tempbuff.s_response;
    filenode-.next := nil;
if not (eof(infile)) then
    readln (infile);
if not (eof(infile)) then
    read (infile, character);
end; (* Procedure ReadStats *)

{******************************************************************************
 * Date: 10/15/95
 * Version: 1.0
 * Name: Sort
 * Module number: 1.6
 * Description: Sorts the frame identifier array into numeric order.
 * Passed Variables: stats
 * Returns: stats
 * Global Variables Used: None
 * Global Variables Changed: None
 * Files Read: None
 * Files Written: None
 * Modules Called: None
 * Calling modules: program CAI_Statistics
 * Author: Capt Frank W. DeMarco
 * History:
 * 1.0 Frank W. DeMarco 10/15/85 - input original code
******************************************************************************}

procedure Sort(var stats: stats_array);

var
    temp : integer4;
    sindx, val, imax : integer;

begin (* Procedure Sort *)

    imax := 0;
    sindx := 1;
    while (stats[sindx] <> 0) do
begin
    imax := imax + 1;
    sindx := sindx + 1
end;
repeat
  sindx := 1;
  for i := 1 to (imax-1) do
    begin
      temp := stats[sindx];
      if (temp > stats[sindx+1]) then
        begin
          stats[sindx] := stats[sindx+1];
          stats[sindx+1] := temp
        end;
      sindx := sindx + 1
    end;
  imax := (sindx-1);
  until (imax = 0);
end; (* Procedure Sort *)

procedure Display;

(* Procedure Sort *)

{**********************************************************************}
 { Date: 10/15/65 }
 { Version: 1.0 }
 { }
 { Name: Display }
 { Module number: 1.7 }
 { Description: Driver for the procedures that display the statistics for }
 { each unique question frame. }
 { Passed Variables: None }
 { Returns: None }
 { Global Variables Used: filenode, filehead, framenode, framehead }
 { Global Variables Changed: filenode, framenode }
 { Files Read: None }
 { Files Written: None }
 { Modules Called: BuildFrameLL, InitDisplay, ShowStats }
 { Calling modules: program CAI_Statistics }
 { Author: Capt Frank W. DeMarco }
 { History: }
 { 1.0 Frank W. DeMarco 10/15/65 - input original code }
{**********************************************************************}

procedure Display;
procedure BuildFrameLL;
begin (* Procedure BuildFrameLL *)
  if (filenode^.ltf_num = stats[dind]) then
    begin
      new (node);
      framenode^.next := node;
      framenode := node;
      framenode^.ltf_num := filenode^.ltf_num;
      framenode^.c_ans := filenode^.c_ans;
      framenode^.s_ans := filenode^.s_ans;
      framenode^.next := nil
    end;
  filenode := filenode^.next;
end; (* Procedure BuildFrameLL *)

*******************************************************************************
* Date: 10/15/85
* Version: 1.0
* Name: InitDisplay
* Module number: 1.7.2
* Description: Initializes variables used in statistical analysis.
* Fulfilled Variables: None
* Returns: None
* Global Variables Used: advance, num_seen, num_right, num_wrong,
  percent_right, percent_wrong, num_A, num_B, num_C
  num_D, num_E, num_Y, num_N
* Global Variables Changed: advance, num_seen, num_right, num_wrong,
  percent_right, percent_wrong, num_A, num_B, num_C
  num_D, num_E, num_Y, num_N
* Files Read: None
* Files Written: None
* Modules Called: None
* Calling modules: Display
* Author: Capt Frank W. DeMarco
* History:
  * 1.0 Frank W. DeMarco 10/15/85 - input original code
procedure InitDisplay;

begin (* Procedure InitDisplay *)

  advance := 0;
  num_seen := 0.0;
  num_right := 0.0;
  num_wrong := 0.0;
  percent_right := 0.0;
  percent_wrong := 0.0;
  num_A := 0;
  num_B := 0;
  num_C := 0;
  num_D := 0;
  num_E := 0;
  num_Y := 0;
  num_N := 0;

end: (* Procedure InitDisplay *)

{*******************************************************************************
 * Date: 10/15/85
 * Version: 1.0
 *
 * Name: ShowStats
 * Module number: 1.7.3
 * Description: Analyzes and displays statistical data stored in the linked
 *               list of frame records (of the same frame).
 * Passed Variables: None
 * Returns: None
 * Global Variables Used: framenode, num_right, num_wrong, num_seen, num_A,
 *                        num_B, num_C, num_D, num_E, num_Y, num_N, tot_r,
 *                        tot_w, percent_right, percent_wrong, linecount
 *                        advance
 * Global Variables Changed: framenode, num_right, num_wrong, num_seen, num_A,
 *                          num_B, num_C, num_D, num_E, num_Y, num_N, tot_r,
 *                          tot_w, percent_right, percent_wrong, linecount
 *                          advance
 * Files Read: None
 * Files Written: None
 * Modules Called: EndScreen
 * Calling modules: Display
 *
 * Author: Capt Frank W. DeMarco
 * History:
 * 1.0 Frank W. DeMarco 10/15/85 - input original code
*******************************************************************************}

procedure ShowStats;

var
  lesson_number, frame_number : integer4;
procedure EndScreen(advance: integer);  

var  
  i : integer;  

begin (* Procedure EndScreen *)
  for i := 1 to (advance - 1) do
    begin
      write ('* ');
      writeln ('*');
    end;
  writeln (ALINEP1,ALINEP2);
  for i := 1 to 24 do
    write ('* ');
  write ('Press RETURN to continue.');
  readln;
  ClearScreen;
  Header;
  linecount := 0
end (* Procedure EndScreen *)

(***********************************************************************)
(* Start of main part of procedure: ShowStats *)
(***************************************************************************)

begin (* Procedure ShowStats *)
  while (framencode <> nil) do
    begin

B - 51
percent_right := (num_right / num_seen) * 100.0;
percent_wrong := (num_wrong / num_seen) * 100.0;
tot := trunc(num_right + 1);  
tot := trunc(num_wrong + 1);
if (linecount = linecount + 1) then
begin
write (*'lesson_number:1,');
write (*'frame-number:');
write (numA:2,');
write (*'numB:');
write (numC:2,');
write (*'numD:');
write (numE:2,');
write (*'percent_right:5.1,');
write (*'percent_wrong:5.1,');
end;
end;
end;
end;
end;

begin
{procedure showstat}
framenode := framehead;

repeat
  BuildFrameLL;
  until (framenode = nil);

InitDisplay;
framenode := framehead^.next;
ShowStats;
end: (* Procedure Display *)

(******************************************************************************
 * Date: 10/15/85
 * Version: 1.0
 *
 * Name: FinalScreen
 * Module number: 1.8
 * Description: Wraps up the screen display after all statistics have been
 *              processed.
 * Passed Variables: None
 * Returns: None
 * Global Variables Used: advance, linecount, dindx
 * Global Variables Changed: advance, dindx
 * Files Read: None
 * Files Written: None
 * Modules Called: ClearScreen
 * Calling modules: program CAI_Statistics
 *
 * Author: Capt Frank W. DeMarco
 * History:
 * 1.0 Frank W. DeMarco 10/15/85 - input original code
******************************************************************************)

procedure FinalScreen;
begin  (* Procedure FinalScreen *)

  advance := DJ - (linecount + 5);
  for dindx := 1 to (advance - 1) do
    begin
      write ('#  ', advance - 1, ' ');
      writeln ('#  ', advance - 1, ' ');
    end;
  writeln (ALINEP1, ALINEP2);
  for dindx := 1 to 26 do
    write (' ');
  writeln ('Press RETURN to end program.');
  readln;
  ClearScreen
end: (* Procedure FinalScreen *)
(* Start of main driver: Program CAI_Statistics *)
(***********************************************************************)

begin (* Program CAI_Statistics *)

ClearScreen;
QueryUser(choice);
ClearScreen;
Init;

writeln ('One moment please... reading statistical collection file.');
while (character in ['1'..'V_LESSONS]) and not (eof(infile)) do

  ReadStats;

Sort(stats);
Header;

linecount := 0;
dind1 := 1;
repeat
  Display;
  dind1 := dind1 + 1;
until (stats[dind1] = 0);

if (choice in ['s','S']) then
  FinalScreen
else
  writeln (ALINEP1,ALINEP2)

end. (* Program CAI_Statistics *)
Appendix C

Files Used by Program "CAI"

File "INTRO"

```
# WW WW EEEEEEE LL CCCCCCC OOOOOO MMM MMM EEEEEEEE
# WW WW WW EE LL CC OO OO MMM MMM EE
# WW WW WW EEEE LL CC OO OO MMM MMM EEEE
# WW WW EE LL CC OO OO MMM MMM EE
# WWW WWW EEEEEE LLLLLLL CCCCCC OOOOOO MM MM EEEEEEEE

TTTTTTTTTT 0000000
TT 00 00
TT 00 00
TT 00 00
TT 0000000

""" CCCCCCCCCCCCCCCC ""
"" CCCCCCCCCCCCC ""
CCC
CCC
CCC
CCC
CCCCCCCCCCCCC
CCCCCCCCCCCCC

THE COURSE YOU ARE ABOUT TO TAKE WAS WRITTEN BY CAPT FRANK DEMARCO
IN PARTIAL FULFILLMENT OF HIS MASTERS DEGREE IN INFORMATION SYSTEMS.

THIS COURSE IS DESIGNED AS AN INTRODUCTORY LEVEL COURSE FOR THE "C"
PROGRAMMING LANGUAGE. THE OBJECTIVE OF THE COURSE IS TO PROVIDE
ENOUGH INFORMATION TO THE STUDENT SO THAT IT MAY BE POSSIBLE FOR
THE STUDENT TO BEGIN USING THE "C" LANGUAGE FOR HIS/HER PROGRAMMING
NEEDS.

THE COURSE, AS IT CURRENTLY EXISTS, CONSISTS OF SIX LESSONS.
```
SELECT THE LESSON YOU WISH TO TAKE FROM THE FOLLOWING:

<table>
<thead>
<tr>
<th>STATUS</th>
<th>LESSON #</th>
<th>LESSON TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>@</td>
<td>1</td>
<td>GETTING STARTED WITH C</td>
</tr>
<tr>
<td>@</td>
<td>2</td>
<td>VARIABLES, CONSTANTS, OPERATORS, EXPRESSIONS</td>
</tr>
<tr>
<td>@</td>
<td>3</td>
<td>PROGRAM CONTROL STATEMENTS</td>
</tr>
<tr>
<td>@</td>
<td>4</td>
<td>POINTERS AND ARRAYS</td>
</tr>
<tr>
<td>@</td>
<td>5</td>
<td>STRUCTURES</td>
</tr>
<tr>
<td>@</td>
<td>6</td>
<td>INPUT AND OUTPUT</td>
</tr>
</tbody>
</table>

Note: A "STATUS" of '+' indicates lesson successfully completed.
The Lesson you are about to take contains introductory information on the course and some general information on C programming.

The Lesson currently consists of five topics.

The Lesson Breakdown is as follows:

Topic 1: Introduction to C CAI course - This topic gives a short introduction to the overall course structure and some of the particulars used in the course. (Approx. time = 5 min.)

Topic 2: C Program Organization - This topic discusses the overall organization and structure of a typical C program. (Approx. time = 15 min.)

Topic 3: C Program Environment - This topic gives a description of the overall C programming environment covering such items as "compiling", and "linking". (Approx. time = 10 min.)

Lesson Breakdown Continued:

Topic 4: Your First C Program - This topic states a problem to be solved and presents a solution for you to help familiarize you with C program statements. (Approx. time = 10 min.)
Topic 5: Lesson 1 Test - This is the lesson test over items that have been presented in the previous four lesson topics. (Approx. time = 5 min.)

TOTAL LESSON TIME IS APPROXIMATELY 45 MINUTES.

I hope that you enjoy it!

SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:

<table>
<thead>
<tr>
<th>STATUS</th>
<th>TOPIC #</th>
<th>TOPIC TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>@</td>
<td>1</td>
<td>Introduction to C CAI Course</td>
</tr>
<tr>
<td>@</td>
<td>2</td>
<td>C Program Organization</td>
</tr>
<tr>
<td>@</td>
<td>3</td>
<td>C Program Environment</td>
</tr>
<tr>
<td>@</td>
<td>4</td>
<td>Your First C Program</td>
</tr>
<tr>
<td>@</td>
<td>5</td>
<td>Test Over Lesson 1</td>
</tr>
</tbody>
</table>

NOTE: A "STATUS" OF "@" INDICATES TOPIC SUCCESSFULLY COMPLETED.

INTRODUCTION TO C CAI COURSE
As a first topic subject I will talk a little about the C programming language computer assisted instruction course as a whole.

C is considered a low-level general purpose programming language.

Its classification as a low-level language does not do it justice though. The language does not provide for, among other things, implicit input or output or for direct file access, but these capabilities can be performed by the use of explicitly called functions (procedures).

The C language is a small, straightforward, easy language to learn.

Let's take a look at what we will be covering in this course.

This course is broken up into six major subject areas. Each of
these six areas are further broken into small topic areas. The goal in organizing the course in this way is to make it easier to understand as well as speed up the process of subject review.

The following is a lesson breakdown of the course:

<table>
<thead>
<tr>
<th>LESSON #</th>
<th>LESSON TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Getting Started With C</td>
</tr>
<tr>
<td>2</td>
<td>Variables, Constants, Operators, Expressions</td>
</tr>
<tr>
<td>3</td>
<td>Program Control Statements</td>
</tr>
<tr>
<td>4</td>
<td>Pointers and Arrays</td>
</tr>
<tr>
<td>5</td>
<td>Structures</td>
</tr>
<tr>
<td>6</td>
<td>Input and Output</td>
</tr>
</tbody>
</table>

12 Let's see if you have been paying attention. How many lessons did I say are in this course?
13 A: Four
13 B: Five
13 C: Six
13 D: Seven
14 Very good! You are paying attention.
14 B: 115
15 ABD No. The correct answer is Six lessons ("C").
15 B: 115
15 E I'm sorry, "E" was not one of your choices.
15 B: 110
11 Frame 110 T
12 What you just saw was an example of one of three types of questions I can ask during the presentation of this course. The other types are True/False and Yes/No questions. The responses that I can recognize are as follows:

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Valid Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Choice</td>
<td>A, B, C, D, E</td>
</tr>
<tr>
<td>True or False</td>
<td>True, False, T, F</td>
</tr>
<tr>
<td>Yes or No</td>
<td>Yes, No, Y, N</td>
</tr>
</tbody>
</table>

Note: For True/False or Yes/No questions I will only look at the first letter of your response, so to save time it's best to enter only T, F, Y, or N. (Answers may be in lower case.)
Let's give it a try.

This is an example of a True/False type question. (True or False)

You are absolutely correct.

Wrong! Are you yanking my electrons?

As you will no doubt notice, there is a test at the end of each lesson. In order for you to receive credit for taking this course you must successfully pass each of these tests.

There is no set lesson order in taking this course, nor is there a requirement to view each topic before taking a lesson test. It is suggested that you do take the course in the order established for reasons of material continuity and in order to enhance understanding.

It is very important that you do not interrupt the CAI program once it has been started. Your progress is only recorded at the end of each lesson topic. Please exit the program by answering "X" at the topic selection menu and the lesson selection menu.

You can check your lesson and topic progress at the selection menus by observing the "status" column displayed.

While taking this course you can be an invaluable aid in making it better by taking note of errors in the course material. If you should notice an error or believe something to be in error, just make a note of where the error appears.

To make this task easier, I display for you all the necessary information. Just record the lesson number, topic number, and of course the frame number of the frame where the error appears. Recording only the frame number will be of little help since each lesson could have a frame with the same number.

I just have one more thing to mention to you before I return you to the topic selection menu.

A word about the lesson tests.

The last lesson topic for each lesson is a test over the material covered in the lesson. As I mentioned before, these tests must be passed in order to receive credit for taking this course.

When you take a test, you will be given information during the test which will help you in locating the material that gave you problems on the test. The way in which this is done is by reference to the
This concludes this topic area. $$$

Frame 300 T C PROGRAM ORGANIZATION

This topic will discuss the overall organization of a typical C program. For ease of understanding, I will restrict the discussion to a program that is contained in one source file.

The organization of the program file would look like the following:

1. Preprocessor Statements Section
2. Global Variable Declarations Section
3. Function(s)
4. Main Program Driver

Each of the above will be discussed in this topic section.

Frame 305 T

*** Preprocessor Statement Section ***

Through the use of a preprocessor, the C compiler has the capability of: file inclusion, token substitution, and conditional compilation.

Preprocessor statement lines are defined in the C program by the use of a # as the first character on a line. These lines may appear anywhere in the program, but it is a good programming practice to place them at the beginning.

We'll take a quick look at each of these preprocessor capabilities.

Which one of the following is "not" a capability of the C preprocessor?

A Conditional Compilation
B Token Substitution
C Function Definition
D File Inclusion

Very good, you're so right.
The preprocessor control line of the form: #include "filename"
will include the contents of the file specified in the source
program file. (Note: The shown quotation marks are needed.)
In addition, a control line of the form: #include <filename>
will include the contents of the "system" file specified.
For example: #include <stdio.h> is the usual statement for
including the file that contains the standard I/O functions
for use with C. We will see more of this later.
One more thing: An included file may also have files included.
This of course should be done cautiously to avoid confusion.

#include file.dat is a valid C preprocessor "file inclusion" statement.
(True or False)
That's right. You need to have quotation marks around the file name.
Wrong. Quotation marks are needed around the file name.
The correct form of the statement is #include "file.dat".

The preprocessor control line of the form:
#define token-name token-replacement
will substitute the value of the token-replacement for each occurrence
of the token-name throughout the program.
For example: If you have a value that might change with time, such
as a mortgage rate, you could use the #define to make future
program changes easier like this ==> #define interest .11
It is easy to see that this capability can be a real time saver. Not
only will it make future program changes easier but it will, with wise
token-name choices, produce an easier to read and maintain program.
Note: #undef token-name is used to cancel the token-replacement.
Which of the following is a valid C preprocessor "token substitution" statement?

A. \#define pay_grade = 11
B. \#declare pay_grade 11
C. \#define pay_grade 11
D. \#declare pay_grade = 11

Correct. Keep up the good work.

A: No. There is no "=" in the valid form of the statement. Answer "C" is the correct response.

B: No. I think you missed something. Let's look at that again.

E: I'm sorry, "E" was not one of your choices.

Conditional Compilation

You can cause the compiler to skip sections of your source code by using the conditional preprocessor control statements of: \#if, \#ifdef, \#ifndef, \#else, and \#endif.

- The statement \#if constant-expression will evaluate to "true" if the constant-expression is a non-zero value.
- The statement \#ifdef identifier will evaluate to "true" if the identifier had previously been defined using the \#define.
- The statement \#ifndef identifier will evaluate to "true" if the identifier had not been previously defined using the \#define.

Following the above statements would be statements that you would want to be executed based on the outcome of the statement test.

Example: \#ifdef employed /* check to see if "employed" \#define(d) */
{ executable statements; }
\#else /* else "employed" is not \#define(d) */
alternate executable statements;

} #endif

#ifndef is an example of a C preprocessor "conditional compilation" statement. (True or False)

Yes, that's right.

Sorry, the answer is "True".

**** Global Variable Declarations Section ****

Whenever a variable is declared independent of a function, it is called a "global" variable. The "scope of a variable" refers to the area where a declared variable is recognized. If you intend to use the same variable in different portions of your program, then it may be desirable to declare the variable as being global.

When you declare a global variable, remember that its "scope" is only those functions (procedures) that physically follow it in the program. (Note: An exception to this involves the "extern" declaration statement which I will cover later.)

Let's look at an example...

#include <stdio.h>

int sum; /* Global Variable "sum" */

main()
{
    sum = 100;
    add();
    add();
    printf("%d", sum);
}

add()
{
    sum = sum + 100;
}

This program would print out the value 300.

Don't worry if you don't follow everything in this example. You will.

The "scope" of a global variable refers to...

the number of variables affected by the global variable.
the extent the global variable is used in the program.

the area preceding the global variable declaration.

the area where a declared global variable is recognized.

the mouthwash of the global variable.

Right.

ABC No. The correct answer is "D".

I'm sorry, variables don't have mouths.

Frame 365 T

*** Functions ***

Following global variable declarations in our typical program example is the area where we define our functions. The structure of a function looks like this:

return-type function-name(arguments, if any)

argument declarations, if any

{ declarations

executable statements

return statement, if any

A function has certain required parts. Here's an example of a function that fills the requirement:

function1() {}
For example: float numval, function1

The above statement would be in the declaration section of the function that calls function1.

The function declaration: float function1(numval)

would be used to identify the called function "function1" and state that the value to be returned by this function is of type float.

Note: We will discuss "float" later.

That brings us to the "function-name" part of the function structure.

The function-name can be of any length but must start with a letter.

Note: The character _ (underscore) is considered a letter in C.

Which of the following is required to follow the function-name in a function declaration statement?

A) " "
B) ( )
C) /
D) # #

Very good.

No. I think your falling asleep. Let's take a step back.

I'm sorry, "E" was not one of your choices.

C - 12
If an argument is not explicitly declared it defaults to type integer.

Following the argument declarations is a required set of braces (). Inside the braces is where the function's declarations, executable statements, and return statement goes. Each statement in this area, as in the argument declaration area, is terminated by the use of a semi-colon.

We'll look at each of the three areas between the braces.

If an argument passed in to a function is not explicitly declared its "type" defaults to an integer. (True or False)

You are absolutely correct.

No. That statement is correct.

Here are the three areas between the () braces.

1. A function will usually have a need to have local parameters and variables defined in order to do its job in the program. The function's declaration section within the braces is where these declarations take place.

2. Following the local declarations is the function's executable statements. These are the statements to be executed by the function prior to returning control to the calling function.

3. The "return" statement is where you identify the variable that is to be passed back to the calling function. The "return" statement can be a bit confusing. There are three forms in which the statement can appear.

The most common form of "return" is: return(expression);

The "expression" can be any valid expression, such as value or just value. In either case the final value will be passed back to the calling function as the value of the function-name. Remember, it is an integer unless explicitly declared otherwise.

Another form of the "return" is: return expression;

The elimination of the parentheses also eliminates the confusion of whether or not "return" is a function (which it isn't).
The last valid form of "return" is: return;
This case has the same effect as leaving out the return statement.
In either case, no value is returned to the calling function and only global variables used by the function would be changed as a result of the called function being executed.

Important Note: **Do Not Use => return(); as this will cause a compile error since "return" is not a function.

We only have one short area left to cover. But first a question.

Which of the following is "not" a valid return statement?

A return(expression);
B return expression;
C+ return();
D return;

Very good!

Wrong. That is a valid return statement. "C" is the invalid one.

"E" was not a given choice. Please try again.

Main Program Driver

This area of the program is usually located at the end of the source program file. It is the required function that starts and ends the programs execution. There must be a function by the name of main() somewhere in your C program.
The organization of the function "main()" is the same as for the functions we just covered. I bet that makes you happy!

Well that about does it for this topic. Let's take one more look at the overall construction of a typical C program before returning to the topic menu.

### Review of C Program Organization ###
The organization of the program file would look like the following:

1. Preprocessor Statements Section
2. Global Variable Declarations Section
3. Function(s)
4. Main Program Driver

*** This concludes this topic area. ***

This topic will discuss the overall C programming environment.

We will follow the complete process of creating a C program from the writing of code to the execution of the resultant executable program.

Although this may sound like a lot to cover, it really isn't.

To get us started let's take a look at the process as a whole.

The following is an outline of the steps we will cover:

1. Create Source File
2. Compile Source File
3. Error Correction
4. Link Object Code Files
5. Run Executable Code File

Let's get started ...

The most important aspect of computer programming in any language is the ability to put your thoughts into computer code. Many experienced programmers feel that the best way to write clear, concise, effective code is to write in plain english "what" it is that needs to be done.

Once the "what" has been identified you can start working on the "how" do I do it question. This brings us to a controversial topic, that of where can I do my best program development? Do I do it on paper, or do I sit at a computer terminal and "create" as I go. Well it all depends on who you talk to as to which way is better, but the person who wrote the program your using now prefers to "create" his programs at the computer terminal. Of course it is not always up to you where you do you programming. Computer time costs money after all, and you and/or your boss should be concerned about such factors.
Whichever way you finally decide to do it, you are going to need a way to put the code you have written into a source file for use on the computer. This calls for the use of a text editor. The more familiar you are with the text editor the easier and faster you can input your code into a source file. Remember, chances are you will have to make error corrections or update your program at some point.

So, learn your text editor and use it often.

Once you have created your C program source file using a text editor, it is time to compile it.

At this point in our C program development we have one source file. The next step is to translate the "source code" in the source file into "object code" in an object file. This translation is accomplished by the C compiler.

The C compiler is actually a program that performs three basic functions using three distinct programs.

1. The C Preprocessor
2. The C Compiler
3. The C Assembler

First, the C "preprocessor" scans the source code for preprocessor statements (# statements) and performs all indicated actions.

Second, the C "compiler" translates the C language statements into computer assembly language statements.

Last, the C "assembler" translates the assembly language statements into the object code and places it in an object file.
This last step occurs if you have not made any C syntax errors!

When you compile your C program, it is possible that you may have made one or two syntax errors. Don't feel bad, it can happen to even the best programmer (once in a while). If this unfortunate occurrence takes place, you can rest assured that the C compiler will let you know.

The C compiler will report any syntax errors that it encounters while compiling your source code. In order to achieve the goal of syntax error free object code, it may be necessary to go through several iterations of "compile & correct".

This process will require changes to your source file, which is a reason why you should know how to use your text editor program inside and out.

Once you have successfully produced an "object code" file, it is time to move on to creating an executable program file.

The C "linker" is a program that is used to link together object files into an executable "machine code" file. The C linker will take all specified object files as well as any needed C library functions and create for you one executable program file.

This feature allows for the creation of user functions that can be used in a variety of programs by merely linking them into the new program. These functions can then be called by the program when needed. This will save you many hours of redundant work.

What now? You ask. Well you'll see, but first a question.

Which one of the following programs will create an executable program file from one or more object files?

A: Compiler
B: Chainer
C: Linker
D: Preprocessor
E: Assembler
Correct.
Wrong. The "Linker" creates the "executable" machine code program file.

Now that you have the executable program file you can sit back and start the seemingly long process of "logic" testing your program.

That's right! It's run time!

At this point, all syntax errors have been corrected and you have successfully created an executable program file. Now you can test your program to your heart's content and make all those changes and/or enhancements to your pride-and-joy (your C program).

Before I return you to the topic selection menu, I would like to give you a picture of the process described in this topic area.

I made no mention of "how" to do the steps only "what" steps needed to be done. The commands to "compile" and "link" differ from system to system, but are similar enough to show an example.

The following is an example of the steps needed to create and run an executable program file.

1. Create Source File ===> progname.c (using a text editor)
2. Compile Source File ===> cc progname.c (using C Compiler)
3. Error Correction ===> (As needed) (using a text editor)
4. Link Object Code Files ===> clink progname (using C Linker)
5. Run Executable Code File ==> progname (type program name)
6. Refine Program Execution ==> (As needed) (using a text editor)

This topic will develop an actual working C program for you to examine.

In order to provide a problem solving structure, here is an outline of the steps that I will be discussing:

1. Problem Definition
2. English Language Problem Solution
3. English Language - C Language Translation
4. C Language Problem Solution

### Problem Definition

The first thing that needs to be done is to define the problem.

The program I want to develop is one that will:

1. Take a one line input from the keyboard, and
2. Display the input line "centered" on the terminal screen.

I will show one way to accomplish this and then allow you to choose whether you want to view an alternate solution.

### English Language Problem Solution

After thinking out the problem, I arrived at the following five step solution:

1. Define and initialize the storage area for one line of input.
2. Prompt user for one line of input.
3. Read in the one line of input keeping track of number of characters read.
4. Calculate number of spaces to precede line for "centered" output.
5. Print out the input line "centered" on screen.

### English Language – C Language Translation

Changing the english problem solution into C language statements we get:

1. 
   ```
   #define CHARIN 80
   char input_line[CHARIN];
   for (i=0; i < CHARIN; i++)
     input_line[i] = ' ';
   ```
2. 
   ```
   printf("Please enter one (1) line of text to be centered.\n");
   ```
3. 
   ```
   while ((c = getchar()) != '\n') {
     input_line[i] = c;
     i++;
   }
   ```
4. 
   ```
   advance = (40 - (i / 2));
   ```
5. 
   ```
   for (ival=0; ival < advance; ival++)
     putchar(' ');
   ```
6. 
   ```
   printf("%s", input_line);
   ```
Now that we have the C statements needed for problem solution, all we need to do is declare the variables we used and put the code into a function called "main".

The following topic frame gives one complete solution.

```
#define CHARIN 80

main() {
    char c, input_line[CHARIN];
    int i, ival, advance;
    for (i=0; i < CHARIN; i++)
        input_line = ' ';
    printf("Please enter one (1) line of text to be centered.\n");
    i = 0;
    while ((c = getchar()) != '\n') {
        input_line[i] = c;
        i++;
    }
    advance = (40 - (i / 2));
    for (ival=0; ival < advance; ival++)
        putchar(' ');
    printf("%s", input_line);
}
```

At this stage of the course, I don’t feel that I should take the time to explain each C statement used in this example program. Please rest assured that I plan to explain all the statements used here as well as a multitude of others later in this course.

The example solution is by no means the only solution to the stated problem, it is only one of many "correct" solutions. It also is not a fool proof solution (Input of > 80 characters is not checked for.).

The rest of this topic area contains an alternate solution to this same problem. Other C statements are shown, but again no explanation is given.
Alternate Solution

In the solution we just finished with, the whole solution was contained in the "main" function. This practice is not a good one to get in the habit of. A better way to solve programming problems is to break the problem solution into small "modules" or, in the case of C, functions.

Earlier I identified several steps to be accomplished in order to solve the example problem. Each main step could be done by its own separate function or we could combine two or more steps into one function. Let's see what we end up with if we use this latter approach.

The first step was "Define and initialize the storage area for one line of input." This of course can be accomplished using a global variable called "CHARIN" having value 80, an array declaration in function "main" of the form: char input_line[CHARIN], and a statement that "blanks" out the array using a "for" statement for control.

These three statements look like the following:

(1) (2) (3)

#define CHARIN 80  
char input_line[CHARIN];  
for (i=0; i < 80; i++)
    input_line[i] = ' ';

The second step of "Prompt user for one line of input" and the third step of "Read in the one line of input keeping track of number of characters read" can be combined into one.

For this we can define a function called "task1" that would look like:

\code{task1(input_line, i)}

char input_line[];
int i;
{ char c;
    printf("\nPlease enter one (1) line of text to be centered.\n");
    while ((c = getchar()) != '\n')
        { input_line[i] = c;
            i++;  }
    return(i);  
}
The fourth step of "Calculate number of spaces to precede line for 'centered' output" and the fifth step of "Print out the input line 'centered' on screen" can be combined into one. For this we can define a function called "task2" that would look like:

```c
int advance, ival;
advance = (40 - (i / 2));
for (ival=0; ival < advance; ival++)
    putchar(' ');
printf("%s", input_line);
```

That just leaves one function to write. That being function "main". I will show two different "main" functions that do the same thing.

```c
for (i=0; i < CHARIN; i++)
    input_line[i] = ' ';
for (i=0; i < CHARIN; i++)
    input_line[i] = ' ';
task2(input_line, i);
task2(input_line, task1(input_line, i));
```

### A Variation To The Problem ###
Now that we have solved the example problem two different ways, how about making a slight improvement to it. What if we wanted to clear the screen before we displayed the "centered" line on the screen?

Well, this can be done fairly easily with the following function:

```c
puts("\033");
puts("H");
puts("\033");
puts("J");
```

Now all we need to do is call "task3" from "task2" before the loop that does the "putchar(' ')". 

C - 22
This is what the "task2" function would then look like:

```c
task2(input_line, i)
char input_line[1];
int i;
{
    int advance, ival;
    advance = (40 - (i / 2));
task3();
for (ival=0; ival < advance; ival++)
    putchar(' ');
printf("%s", input_line);
}
```

Of course, "task3" would be located ahead of "task2" in the program source file.

Let's see what our program source file would look like if we use this alternate program solution with the "clear screen" function.

```c
#define CHARIN 80

++++> task3()
;
++++> +++ task2(input_line, i)
;
++; +++++> task1(input_line, i)
;
++; +++++++ main

The way to read this is: "main" calls "task1", then "main" calls "task2", then "task2" calls "task3".
```

Well, that about does it for lesson number one. If you have seen the four subject topics in this lesson, you should now be ready to take the final test. If you feel that you don't understand something well enough to pass the test, please retake the topic that is giving you problems.

Topic 1 gave an introduction to the C CAI course structure.
Topic 2 gave a description of the C program organization.
Topic 3 gave a description of the C program environment.
Topic 4 presented a programming example for your inspection.
Welcome to the final test of lesson one. This test consists of ten questions over material presented in the previous four topic areas. In order to successfully complete this lesson, you must achieve a minimum score of 70% (seven out of ten questions correct). If you miss a question, the correct answer will not be shown. It is up to you to research the correct answer. Well, enough said. Let's get on with it. Good luck!

1. After answering a test question in this course, a reference is shown to you so that you can find the place in the lesson where the question originated. The reference is in the format of (#,@) where ...
   A) # = lesson number and @ = frame number
   B) # = lesson topic number and @ = topic frame number
   C) # = lesson topic number and @ = lesson line number
   D) # = lesson number and @ = lesson topic number

2. The three capabilities of the C preprocessor are: file inclusion, token substitution, and conditional compilation. (True or False)
   A) True
   B) False

3. Which of the following is a valid C preprocessor "token substitution" statement?
   A) #define interest .09
   B) #declare interest .09
   C) #define interest = .09
   D) #declare interest = .09

4. Which of the following is a valid C preprocessor "token substitution" statement?
   A) #define interest .09
   B) #declare interest .09
   C) #define interest = .09
   D) #declare interest = .09
Which of the following is "not" a valid C preprocessor "conditional compilation" statement?

A #if

B #ifdef

C #else

D #for

E #ifndef

Right. (2,320)

Wrong. (2,320)

The function name in a function declaration can consist of any combination of letter, digits, or characters on the keyboard. (True or False)

Right. (2,355)

Wrong. (2,355)

Which of the following is the required function in a C program that usually starts and ends execution of the program?

A start()

B begin()

C main()

D driver()

Right. (2,320)

Wrong. (2,320)

"E" was not one of your choices.

Which of the following is a list of the three programs contained in the C compiler?

A Preprocessor, Compiler, Linker

B Preprocessor, Compiler, and Assembler
53C Compiler, Assembler, and Linker
53D Editor, Preprocessor, Assembler
54 Right. (3,515)
54 B:940
55ACD Wrong. (3,515)
55 B:940
55E "E" was not one of your choices.
55 B:935
51Frame 940 OP
52B. The C "Linker" is a program that is used to link together one or more
52object files into an executable "machine code" file. (True or False)
53Y
54 Right. (3,530)
54 B:945
55 Wrong. (3,530)
55 B:945
51Frame 945 OM
5210. Which of the following is a "Compiler" program that translates the
52C language statements into assembly language statements?
53A Editor
53B Preprocessor
53C Compiler
53D Assembler
53E Linker
54 Right. (3,520)
54 B:950
55ABDE Wrong. (3,520)
55 B:950
51Frame 950 OM
5210. What is the first thing that needs to be done when solving a computer
52programming problem?
53A Define the problem to be solved.
53B Write the "english" language solution.
53C Do an "english" to "C" language translation.
53D Write the "C" language solution.
54 Right. (4,700)
54 B:955
55BCD Wrong. (4,700)
55 B:955
55E "E" was not one of your choices.
55 B:950
This marks the end of lesson number one. I hope that it was of some benefit to you. I am looking forward to seeing you in lesson number two. I hope that you didn’t have too much trouble with the material presented in this lesson. If you did, please voice your comments to your training monitor who will in turn contact the CAI Plans Branch at Keesler AFB, MS.

Well, let’s take a look at how you did with the test ...
THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INFORMATION ON VARIABLES, CONSTANTS, OPERATORS, AND EXPRESSIONS USED IN C PROGRAMMING.

THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.

The Lesson Breakdown Is As Follows:

Topic 1: Variables & Constants I - This topic is the first of two that covers the declaration and use of variables and constants in C programming. (Approx. time = 10 min.)

Topic 2: Variables & Constants II - This topic is the second of two that covers the declaration and use of variables and constants in C programming. (Approx. time = 5 min.)

Topic 3: Operators & Expressions I - This topic is the first of two that covers the use of the different operators and expressions in C programming. (Approx. time = 15 min.)

Lesson Breakdown Continued:

Topic 4: Operators & Expressions II - This topic is the second of two that covers the use of the different operators and expressions in C programming. (Approx. time = 10 min.)
Topic 5: Lesson 2 Test - This is the lesson test over items that have been presented in the previous four lesson topics. (Approx. time = 5 min.)

TOTAL LESSON TIME IS APPROXIMATELY 45 MINUTES.

I hope that you enjoy it!

SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:

<table>
<thead>
<tr>
<th>STATUS</th>
<th>TOPIC #</th>
<th>TOPIC TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Variables &amp; Constants I</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Variables &amp; Constants II</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Operators &amp; Expressions I</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Operators &amp; Expressions II</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Test Over Lesson 2</td>
</tr>
</tbody>
</table>

NOTE: A "STATUS" OF "*" INDICATES TOPIC SUCCESSFULLY COMPLETED.

In C there are four sets of basic data types that can be used. These four are: Character, Integer, Floating point, and Double-precision floating point.

We will cover the character and integer data types in this topic area, and leave floating point and double-precision floating point for the next topic area.

I will be discussing the declaration and use of both variables and constants within the context of data type usage.

The flow of this topic area will follow the following outline:

1. Character Constants
2. Integer Constants
3. Character Variables
4. Integer Variables
Before we get too far into this area, we need to set up some rules for naming any variables that we use in our programming.

1. Variable names must begin with a letter.
2. Variable names are composed of letters and digits.
3. Variable names must not be C keywords.

In C, a "letter" is any character in the set (a..z,A..Z,_, that’s all lower and upper case letters as well as the "underline" character. A "digit" is any character in the set (0..9). A "keyword" is any word in the set:
(auto, break, case, char, continue, default, do, double, else, entry, extern, float, for, goto, if, int, long, register, return, short, sizeof, static, struct, switch, typedef, union, unsigned, while)

A few additional facts need to be mentioned about variable names.

1. Upper and lower case names are different. This means that the variable names: answer, Answer, and ANSWER are all different variable names.
2. Only the first eight characters of a variable name are significant. This means that insert_A1 and insert_A2 are the same variable name.
3. The number of significant characters may be less than eight for external variables and function names (system dependent).

Which of the following is "not" a valid variable name?

A. X123
B. first_num
C. 2nd_in_line
D. _OUT_

Very good!

No. The correct answer is "C". Variable names must start with a letter.

I'm sorry, "E" was not one of your choices.

*** Character Constants ***
A character constant is symbolized as a single character enclosed within single quotation marks.

For example: 'a'

The value of a character constant is actually the numeric equivalent of the character as defined by the computer system's character set. Thus, arithmetic operations using characters is possible but the most common use for character constants is for comparative purposes.

All this may seem confusing, but it really isn't. We will look at an example of the usage of character constants after we take a look at character variables.

### Character Variables

A character variable is declared by the use of the keyword: char

For example: char in_char;

The character variable "in_char" will now be assigned a one byte storage location in the computer's memory. The value that will be stored in this location depends on the usage of the variable in the program. Let's look at a couple examples that should help you understand both character variables as well as character constants.

The statement: in_char = 'a'; assigns the ASCII value 97 (decimal) to the character variable location identified by "in_char" in memory.

Note: ASCII values range from 0 thru 127 (decimal) and can be found in most good programming books.

### Character Variables Continued

Every character on the keyboard has an ASCII numeric equivalent. (By the way, ASCII stands for American Standard Code for Information Interchange.) There are, however, several characters that are hidden. These characters can be represented by character constants by using character escape sequences that start with a backslash (\).

Some of the more common character escape sequences follow:

\b (backspace)
\n (new line)
\t (form feed)
\r (carriage return)
\\ (backslash)
\' (single quotation)
\### (### = an octal value)
An example of how you would declare a character variable using one of the special character escape sequences as a character constant is as follows:

cchar back_space = '\b';

This statement assigns the ASCII value 8 (decimal) to the character variable location identified by "back_space" in memory.

An equivalent way to declare the variable "back_space" is as follows:

cchar back_space = '\010'; OR cchar back_space = '\10';

In both statements, the character variable location "back_space" is assigned the value 10 (octal) which is equivalent to 8 (decimal).

In the statement: cchar input_char = 't';

input_char is called a character variable and 't' is called a character constant. (True or False)

That's right.

Wrong. That is a true statement.

Which one of the following characters is used to identify a special character escape sequence?

A $  
B @  
C &  
D+ \  
E #

Very good, you're so right.

No. Answer "D" is the correct answer.

So far in this topic area you have seen rules over selecting variable names, a description and examples of character constants, a description of character constants, and a description of examples of
how to declare special characters.
In the remainder of this topic area we will look at integer constants and integer variables.
So let's get to it ...

*** Integer Size ***
The first thing we need to cover when talking about integers is the size of a number that can be used. In C we can normally use integers in the range: 

$-32,768$ thru $32,767$

If it is necessary to use a number outside this range, C provides a way to accomplish this.
The use of an "unsigned" integer provides for use of numbers in the range: $0$ thru $65,535$
The use of a "long" integer will provide for use of numbers in the range: 

$-2,000,000,000$ thru $2,000,000,000$

The way to identify which size you are using will be explained.

*** Integer Constants ***
An integer constant can be expressed in one of three ways. It can be decimal, octal, or hexadecimal. Also, each of these can be either a "short" or "long" integer.

Decimal integer constants are represented by such numbers as: $238$, $45920$, and $-72$. Note that embedded commas are not used. $45,920$ would be wrong.

Octal integer constants are represented by such numbers as: $089$, $0150$, and $014$. Note that "octal" numbers all have a leading "zero".

Hexadecimal integer constants are represented by such numbers as: $0xBF$, $0x9f$, $0x2A$, and $0x7b$. Note that lower case and upper case can be used and "hexadecimal" numbers all have a leading "zero x".

*** Integer Constants Continued ***
As I mentioned, integer constants can also be either a "short" or "long" integer. An integer will be stored as a "short" integer unless you indicate otherwise. There is, of course, exceptions to the rule. For example, if you specify an integer that is larger than $32767$, then it will be stored as a long integer.
The way to indicate that an integer is to be stored as a "long" integer is to follow the number with the letter "L". Here are a few examples.

Decimal: 5987L, and 367L
Octal: 04689L, and 0824L
Hexadecimal: 0X2A5F4L, and 0xFDAL

Note: A lowercase letter "1" may be used, but may be very confusing.

Which of the following best describes the integer constant 073564L?

A. Decimal
B. Long Decimal
C. Octal
D. Long Octal
E. Hexadecimal

Right.

No. The "0" (zero) in front makes it an "octal" and the "L" makes it a "long" integer. I think you need to review this material.

No. The "0" (zero) in front makes it an "octal" number.

No. The "L" after the number makes it a "long" octal number.

An integer variable is declared by the use of the keyword: int

For example: int index;

The integer variable index will now be assigned a 16 bit storage location in the computer's memory.

Let's look at a couple examples that should help you understand both integer variables as well as integer constants.

The statement: number_in = 212; assigns the integer constant value 212 (decimal) to the integer variable location identified by "number_in" in memory.

When declaring an integer variable, you have the option of specifying whether the variable is to be a "short", "long", or "unsigned" variable.
The way to indicate which of these an integer variable will be is by using the keywords short, long, or unsigned. Here are some examples:

- short int index_1; or Just short index_1;
- long int index_2; or Just long index_2;
- unsigned int index_3; or Just unsigned index_3;

Note: When using these keywords, use of "int" is optional.

When declaring an integer variable, you only have the option of specifying the variable as being either "short" or "long". (True or False)

That's right. You can also specify it as being "unsigned".

Wrong. You can also specify it as being "unsigned".

One last word on integers.

Although C has the capability of specifying different size storage locations, this capability is limited by the specific compiler and system you are using. Please check to see if your compiler and system treat integers as described here.

In this topic area we have looked at a description and examples of character constants, character variables, integer constants, and integer variables. Also we covered variable names and special characters.

In the next topic area we will continue to discuss constants and variables by looking at floating point and double-precision floating point data types.

This concludes this topic area.
so we will cover floating point and double-precision floating point in this topic area.

I will be discussing the declaration and use of both variables and constants within the context of data type usage.

The flow of this topic area will follow the following outline:

1. Floating Point and Double-precision Floating Point Constants
2. Floating Point Double-precision Floating Point Variables

Floating point numbers are just numbers that have two parts instead of one, as in the case of an integer. You can think of a floating point number as having an integer, or whole part, and a fractional part.

These two parts are separated by a decimal point.

Examples of floating point numbers: 67.32, 2583.1, and 2.4592

How "precise" a number is has an effect on calculations performed using a stored number. Thus, the precision of a number may be very important within your program. C stores all floating point constants as double precision. This means that a large number of significant digits are stored to represent the number and hence, gives better precision in any calculations performed involving the number.

Another way of representing floating point numbers is through the use of "scientific notation". The following are examples of the use of scientific notation for floating point constants:

4.67E3 = 4670.0
.9834E2 = 98.34
.345.0e6 = 345000000.0
-2.8473E5 = -284730.0

4.67E-3 = .00467
.9834E-2 = .009834
.345.0e-6 = .0000345
-2.8473E-5 = -.00028473

Note: The "E" can be upper or lower case ("e").

Which of the following is "not" an example of a floating point constant?

4670.0
In C, floating point variables are declared using the keyword "float", and double precision floating point numbers are declared using the keyword "double".

Here are some examples:

```c
float var_1;  // double var_1;
float var_2, var_3;  // double var_2, var_3;
```

The following illustrates the use of floating point constants and variables.

```c
float var_1 = 451.29  // or float var_1 = 4.5129E2
double var_2 = 23975.5619  // or double var_2 = 2.397535619e4
```

To reiterate, the use of "double" allows for the storing of a greater number of significant digits to represent a given number. Thus, more precision is gained in calculations involving the number.

Another way of achieving the precision of a double precision variable is with the keyword "long". The following two statements have the same effect:

```c
double var_1;  // >>>>>> OR >>>>>> long float var_1;
```

In the statement `double var_one = 419.9253;` the keyword "double" is used to indicate that variable "var_one" is to be stored as a "double precision floating point" number. (True or False)

Very good.

That statement is true.
### Topic Summary ###

In this topic area we have looked at a description and examples of floating point and double precision floating point constants, and floating point and double precision floating point variables.

In the next topic area we will begin a discussion of operators and expressions and their use in C.

### This concludes this topic area. ###

---

#### OPERATORS & EXPRESSIONS I

**Introduction**

In this and the next topic area we will be discussing operators and their use in expressions.

This first topic area will cover the following:

1. Arithmetic Operators
2. Increment & Decrement Operators
3. Assignment Operators

Let's get started ...

---

#### Arithmetic Operators

The arithmetic operators are represented by the following:

- Addition (+), Subtraction (-), Multiplication (*), Division (/), Modulus (%), and the Unary minus (-).

The first four in this list are probably the most familiar to you so I will only give one example of their use in an expression.

**Addition**: \( a + b \) (adds \( b \) to \( a \))

**Subtraction**: \( a - b \) (subtracts \( b \) from \( a \))

**Multiplication**: \( a \times b \) (multiplies \( a \) by \( b \))

**Division**: \( a / b \) (divides \( a \) by \( b \))

---

The modulus operator can be used only with integer (int) data types.

The action performed by this operator is one of returning the remainder
after a division operation. For example, in the statement:

Answer = 15 % 2; the value stored in "Answer" would be 1, since 15
divided by 2 is 7 with a remainder of 1. Likewise:

Result = 150 % 15; produces a value of 0 in "Result", since 15 divides
150 evenly.

Arithmetic Operators Continued

The unary minus operator is used to change the sign of the operand it
operates on.

The action performed by this operator is one of returning the negative
of the value of the operand. For example, in the statement:

Answer = -x_value; the value stored in "Answer" would be the negative
of the value stored in "x_value". For instance:

If the value stored in "x_value" is 385, then the value stored in the
variable "Answer" would be -385. Likewise, if the value in "x_value"
were -952, then "Answer" would contain the value 952.

Note: C does not have a unary plus operator.

Which of the following is the value that will be assigned to the variable
"Answer" after execution of the statement: Answer = 27 % 12; ?

A 2.25
B 3
C .25
D 2

Very good.
B:525

No. The modulus operator returns the "remainder" of "integer" division,
therefore answer "B" is correct.
B:525

I'm sorry, "E" was not one of your choices.
B:520

### Increment & Decrement Operators ###

The increment and decrement operators are represented by the following:

Increment (++) and Decrement (--)

These two operators can be used in either "prefix" or "postfix"
notation.
"Prefix" notation results in the variable being incremented or decremented before its value is taken. Whereas, "postfix" notation results in taking the variable value before it is incremented or decremented.

Let's take a look at each of these operators and see how "prefix" and "postfix" affects them.

**Increment Operator**

In the statement: x_value = x_value + 1; the value of x_value is incremented by 1 and restored in the memory location identified by the variable "x_value". This is a valid statement in C, but C also allows a shorthand way of doing the same thing. In this shorthand notation, the statement would be written as x_value++; Thus:

x_value = x_value + 1; and x_value++; are equivalent statements.

The above example also demonstrates the use of "postfix" notation. The same result could have been obtained by using "prefix" notation. If you were to use the statement: ++x_value; the stored value of "x_value" would have been incremented by 1 as it was using the other two statements. Where's the difference then? Well, let's look at another example and see if it becomes clearer.

**Increment Operator Continued**

If we assign the value of 10 to the variable "x_value" using the statement: x_value = 10; and then perform some arithmetic operation using the variable "x_value" and the increment operator, what would be the result?

Well, it all depends on whether you use "prefix" or "postfix" notation.

If we perform the statement: Result = ++x_value; then the value stored in "Result" is 11, and "x_value" is incremented to 11, but if we perform the statement: Result = x_value++; then the value stored in "Result" is 10, and "x_value" is incremented to 11.

As you can see, this can be confusing until you get used to the idea.

The placement of the "increment" operator (either before or after the variable) has no effect on the outcome of statement execution.

(True or false)

Right.

Wrong. variable++ and ++variable will produce different results depending on how and when they are used.
In the statement: \( y_{\text{value}} = y_{\text{value}} - 1; \) the value of \( y_{\text{value}} \) is decremented by 1 and restored in the memory location identified by the variable "\( y_{\text{value}} \)." This is a valid statement in C, but again C has a shorthand way of doing the same thing. In this shorthand notation, the statement would be written as \( y_{\text{value}}--; \) Thus:
\[
\begin{align*}
y_{\text{value}} &= y_{\text{value}} - 1; \\
y_{\text{value}} &= y_{\text{value}}--;\end{align*}
\]
are equivalent statements.

The above example again demonstrates the use of "postfix" notation. The same result could have been obtained by using "prefix" notation. If you were to use the statement: \( --y_{\text{value}}; \) the stored value of "\( y_{\text{value}} \)" would have been decremented by 1 as it was using the other two statements. Let's again look at an example showing the difference between using "prefix" and "postfix" notation.

If we assign the value of 15 to the variable "\( y_{\text{value}} \)" using the statement: \( y_{\text{value}} = 15; \) and then perform some arithmetic operation using the variable "\( y_{\text{value}} \)" and the decrement operator, what would be the result?

Well, again it all depends on whether you use "prefix" or "postfix" notation.

If we perform the statement: \( \text{Answer} = --y_{\text{value}}; \) then the value stored in "\( \text{Answer} \)" is 14, and "\( y_{\text{value}} \)" is decremented to 14, but if we perform the statement: \( \text{Answer} = y_{\text{value}}--; \) then the value stored in "\( \text{Answer} \)" is 15, and "\( y_{\text{value}} \)" is decremented to 14.

Remember: prefix - value taken second, postfix - value taken first.

Which of the following represents the contents of variables "\( \text{Answer} \)" and "\( y_{\text{value}} \)" after execution of the statement: \( \text{Answer} = 25 + (--y_{\text{value}}); \) given the initial value of "\( y_{\text{value}} \)" is 10?

A+ \( \text{Answer} = 16 \) and \( y_{\text{value}} = 9 \)
B \( \text{Answer} = 15 \) and \( y_{\text{value}} = 9 \)
C \( \text{Answer} = 16 \) and \( y_{\text{value}} = 10 \)
D \( \text{Answer} = 15 \) and \( y_{\text{value}} = 10 \)

You are correct.
I'm sorry, "E" was not one of your choices.

The assignment operators are represented by the following:

Equal (=), and Operation equal (op=), where the "operation" is one of the binary operators.

We have already seen how the first assignment operator is used. As an example we have a statement such as: Answer = 25;

In this example, the equal assignment operator is used to place the value of 25 in the memory location represented by the variable "Answer". This assignment is done "right to left", so it is possible to make several assignments using one statement. For example:

a_val = b_val = c_val = 0; will set all the named variables to zero.

The "operation equal" operators are really nothing more than a shorthand method of writing a statement that involves doing some operation on a variable and storing the result back into that variable's memory location. For example, in the statement:

x_value = x_value + 25; 25 is added to the value of x_value and the result is stored in the memory location represented by x_value.

C provides a way to accomplish this in a shorter statement (although the one above is also valid). An equivalent C statement would be:

x_value += 25;

All operations on the right will be done before the operation identified in front of the "=" sign.

That last statement is an important one. For example, in the statement

a_val %= b_val + c_val; you will get a different result if the statement were evaluated as: a_val = (a_val % b_val) + c_val;

To eliminate this problem, C will evaluate the statement according to the following rule:

left_variable = (left_variable) "op" (right_expression);

Our example will be evaluated as: a_val = (a_val) % (b_val + c_val);
The result stored in "x_value" after execution of the statement:
32x_value -= 35 + 20; given an initial value for "x_value" of 100,
32would be 45. (True or False)
33Y
34Right.
34B:580
35Wrong.
35B:580
31Frame 580 T
32### Topic Summary ###
32In this topic area we have looked at a description and examples of
32arithmetic, increment & decrement, and assignment operators.
32In the next topic area we will continue our discussion of operators
32and expressions and their use in C.
32
32### This concludes this topic area. ###
33END
31Frame 700 T OPERATORS & EXPRESSIONS II
42### Introduction ###
42In this topic area we will be continue discussing the use of operators
42in expressions that we started in the last topic area.
42This second topic area on this subject will cover the following:
421. Relational Operators
422. Logical Operators
423. Bitwise Logical Operators
424. Negation Operator
425. Conditional Operator
42
42Let's get started ...
43B:705
41Frame 705 T
42### Relational Operators ###
42Relational operators are used within a program in order to compare
42one or more data values. The relational operators are represented
42by the following:
42Equality (==), Inequality (!=), Greater than (>), Greater than or
42equal to (>=), Less than (<), and Less than or equal to (<=).
42Expressions involving these operators are evaluated as being either
42"true" or "false". If an expression is "true" then the expression
42has a value of 1 (one), if it is "false" than the value is 0 (zero).
Let's take a look at an example to help make this clear.

For our example let's compare two variables:

\[
\text{var}_1 \geq \text{var}_2\]

is an expression that has a value of either "true" or "false". If \(\text{var}_1\) is indeed greater than or equal to \(\text{var}_2\), then the expression is "true" and has a value of 1 (one). Likewise, if \(\text{var}_1\) is not greater than or equal to \(\text{var}_2\), then the expression is "false" and has a value of 0 (zero).

In order to give this evaluation meaning, it must be somehow used in a valid C statement. An easy to understand example is:

\[
\text{var\_flag} = (\text{var}_1 \geq \text{var}_2);
\]

"\text{var\_flag}\" will be assigned either 1 or 0 depending on the evaluation of the expression: \(\text{var}_1 \geq \text{var}_2\).

The example we looked at was one in which a comparison was made between two variables. This is not the only way to use the relational operators as you can well imagine.

Some of the more common situations that relational operators are used in include: comparing array values, checking for "end of file", controlling function calls, and controlling statement execution.

Relational operators have a lower precedence than arithmetic operators, and assignment operators have lower precedence than relational operators. Thus, the statement: \(\text{val\_one} = \text{val}_2 \neq \text{val}_3 - 5\); will be evaluated as: \(\text{val\_one} = (\text{val}_2 \neq (\text{val}_3 - 5))\); The final value of either 1 or 0 will eventually be stored in the memory location represented by the variable "\text{val\_one}\".

Which of the following is "not" a relational operator?

- A \(\leq\)
- B \(!=\)
- C \(\geq\)
- D \(<\)
- E \(+ ++\)

Right.
Logical operators are also called logical connectives and they are used to combine expressions being used for comparison. The logical operators are represented by the following:

Logical AND (&&) and Logical OR (||)

Expressions involving these operators are evaluated as being either "true" or "false". If an expression is "true" then the expression has a value of 1 (one), if it is "false" than the value is 0 (zero).

Let's take a look at an example.

In the expression: in_char == 'y' || in_char == 'n', the value of the expression can once again have a value of either 1 or 0 depending on whether the expression is "true" or "false".

In order to give this evaluation meaning, it must be somehow used in a valid C statement. An example is:

valid_resp = (in_char == 'y' || in_char == 'n');

"valid_resp" will be assigned either 1 or 0 depending on the evaluation of the expression: in_char == 'y' || in_char == 'n'

In other words, valid_resp will be 1 if in_char equals either y OR n, or 0 if in_char equals anything else.

Logical operators have a lower precedence than relational operators, and assignment operators have lower precedence than logical operators thus, the statement:

result_val = val_1 < val_2 && val_3 != val_4;

is evaluated as: result_val = ((val_1 < val_2) && (val_3 != val_4));

The final value of either 1 or 0 will eventually be stored in the memory location represented by the variable "result_val".
the value of "True_Response" will be set to 1, only if both "choice == 't'"
and "choice == 'T'" are true. (True or False)

That's right.

Wrong. Only one of the expressions has to be true when using the "OR"
logical operator.

Bitwise logical operators are represented by the following:

Bitwise AND: &
Bitwise inclusive OR: |
Bitwise exclusive OR: ^
Left shift: <<
Right shift: >>
Unary one's complement: ~

The negation operator is a unary NOT operator. It is used to convert
or reverse the value of the operand it appears in front of.

The exclamation point (!) is used for this operator.

For example, in the expression: !(val_one < 30) if the value of the
inner expression is "true" then the value of the entire expression is
"false", and vice versa.

The parentheses, in this case, are necessary since the negation oper-
ator has a higher precedence than relational operators.

A statement using the negation operator would look something like this:

control_flag = ! found_flag;

The conditional operator is what is called a "ternary" operator.

What this means is that the operator acts upon three operands. The
effect it has is very similar to an "if-else" control statement.

The conditional operator is represented by a question mark and colon.
### Conditional Operator Continued

For example, in the statement:
```
new_val = val_1 == 1 ? new_val = 25 : new_val = 30;
```

The final value of "new_val" depends on the value of "val_1". If
val_1 is equal to 1, then the expression "val_1 == 1" is true and
the expression "new_val = 25" will be executed, else if "val_1 == 1"
is false, then the expression "new_val = 30" will be executed. The
value of new_val will be stored in the memory location represented
by the variable "new_val" because of the assignment operator "="
after the variable "new_val" on the left side of the statement.

---

In the statement: `val_1 = test_val ? val_1 = 1 : val_1 = 0;`
if `test_val` equals 1, then the value of `val_1` will be 1. (True or False)

Right.

Wrong. "val_1 = 1" would be executed, thus setting "val_1" equal to 1.

---

Well, that about does it for lesson number two. If you have seen the
four subject topics in this lesson, you should now be ready to take
the final test. If you feel that you don’t understand something well
enough to pass the test, please retake the topic that is giving you
problems.

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<thead>
<tr>
<th>Topic #</th>
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<td>Real &amp; double precision real constants and variables.</td>
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<td>3</td>
<td>Arithmetic, increment &amp; decrement, and assignment operators.</td>
</tr>
<tr>
<td>4</td>
<td>Relational, logical, negation, and conditional operators.</td>
</tr>
</tbody>
</table>

Welcome to the final test of lesson two. This test consists of ten
questions over material presented in the previous four topic areas.
In order to successfully complete this lesson, you must achieve a
minimum score of 70% (seven out of ten questions correct).
If you miss a question, the correct answer will not be shown. It is
up to you to research the correct answer.
Well, enough said. Let's get on with it. Good luck!

521. Which of the following is not a valid variable name?
53A  $x_{1.y2}$
53B  int
53C  _IN_
53D  var
54 Right.  (1,105)
54 B:910
55ACD Wrong.  (1,105)
55 B:910
55E "E" was not one of your choices.
55 B:905

522. A character constant is symbolized as a single character enclosed within single quotation marks. (True or False)
53Y
54 Right.  (1,120)
54 B:915
55 Wrong.  (1,120)
55 B:915

523. Which one of the following characters is used to identify a special character escape sequence?
53A  #
53B  +
53C  \n
53D  %
54 Right.  (1,130)
54 B:920
55ABD Wrong.  (1,130)
55 B:920
55E "E" was not one of your choices.
55 B:915

524. In the statement: double var_one = 358.8204; the keyword "double" is used to indicate that variable "var_one" is to be doubled in value before being stored in the memory location represented by "var_one". (True or False)
53N
54 Right.  (2,315)
54 B:925
55 Wrong.  (2,315)
55 B:925

C - 48
525. Which of the following is "not" an arithmetic operator?

A
B
C
D

Right. (3,505)
B:930

ABC Wrong. (3,505)
B:930

E "E" was not one of your choices.
B:925

SBCD Wrong. (3,510)
B:935

E "E" was not one of your choices.
B:935

P:935

526. Which of the following is the value that will be assigned to the variable "Answer" after execution of the statement: Answer = 22 % 5;

A
B
C
D

Right. (3,510)
B:935

BCD Wrong. (3,510)
B:935

E "E" was not one of your choices.
B:930

Frame 935 QP

527. The placement of the "increment" (++) or decrement (--) operators, with respect to the variable they operate on, never has an effect on the outcome of statement execution.

N

Right. (3,530 & 545)
B:940

Wrong. (3,530 & 545)
B:940

Frame 940 QP

528. The result stored in "Answer" after execution of the statement: Answer *= 10 + 10; given an initial value for "Answer" of 10, would be 220. (True or False)

N

Right. (3,555)
B:945

Wrong. (3,555)
B:945

Frame 945 QP

529. Which of the following is "not" a relational operator?

A
B


53B <=
53C ==
53D+ +=
54 Right. (4,705)
54 B:950
55ABC Wrong. (4,705)
55 B:950
55E "E" was not one of your choices.
55 B:945
51Frame 950 QM
5210. Which of the following represent the logical operators "OR" and "AND"?
53A || and ~
53B ~ and &&
53C ## and ::
53D+ :: and &&
53E @@ and ++
54 Right. (4,720)
54 B:955
55ABCE Wrong. (4,720)
55 B:955
51Frame 955 T
52 *** End of Lesson Material ***
52
52 This marks the end of lesson number two. I hope that it was of some
52 benefit to you. I am looking forward to seeing you in lesson number
52 three. I hope that you didn’t have too much trouble with the material
52 presented in this lesson. If you did, please voice your comments to
52 your training monitor who will in turn contact the CAI Plans Branch
52 at Keesler AFB, MS.
52
52 Well, let’s take a look at how you did with the test ...
53END
The Lesson You Are About To Take Contains Information On Program Control Statements Used In The C Programming Language.

The Lesson Currently Consists Of Five Topics.

The Lesson Breakdown Is As Follows:

Topic 1: If, If-Else, Nesting, and Switch - This topic gives descriptions of the structure and use of the If and If-Else control statements and how to "nest" these statements. Also covered in this topic is the Switch control structure. (Approx. time = 15 min.)

Topic 2: Loops (While, For, and Do-While) - This topic discusses the structure and use of loop statements. (Approx. time = 15 min.)

Topic 3: Break and Continue Statements - This topic gives a description of the Break and Continue statements and how and when they are used. (Approx. time = 10 min.)

Lesson Breakdown Continued:

Topic 4: Goto statement and Labels - This topic gives a description of the Goto statement and the use of labels within a C program. (Approx. time = 5 min.)
Topic 5: Lesson 3 Test - This is the lesson test over items that have been presented in the previous four lesson topics. (Approx. time = 5 min.)

TOTAL LESSON TIME IS APPROXIMATELY 50 MINUTES.

I hope that you enjoy it!

----------------------------------------------------------------------------------

SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:

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<td>@</td>
<td>5</td>
<td>Test Over Lesson 3</td>
</tr>
</tbody>
</table>

*******************************************************************************

NOTE: A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.
*******************************************************************************

Frame 100 T If, If-Else, Nesting, Switch

### Control Statements ###

Control statements are used in programming languages to provide a means of altering the "normal" flow of the program.

Without the use of control statements, program execution would proceed in a sequential fashion starting with the first executable statement and ending with the last executable statement. In most cases this is not the desired way in which the programmer wants the program to execute. Thus, the need and capability for imposing control over program execution using program control statements.

The control statements that we will be looking at in this topic are the "if", "if-else", and "switch". We will also cover "nesting" of "if" statements.

Let's get started.
The "if" statement is used to control the execution of a statement or statements by testing an expression. The expression is checked to see if it is "true" (non zero) or "false" (zero). If the statement is indeed "true", then the statement (or statements) following the "if" is executed. If the expression is "false", then the next sequential statement is executed.

The structure of the basic "if" statement is as follows:

```c
if (test_expression)
    statement_to_be_executed;
next_sequential_statement;
```

Let's take a look at an actual example of the basic "if" statement.

For this example let tax_val, high_tax, and tax_rate be of type "int".

```c
if(tax_val >= 10)
    high_tax++;
    tax_rate = tax_val / 100;
```

In this example, the expression "tax_val >= 10" is tested. If the value of "tax_val" is greater than or equal to 10, then the statement "high_tax++;" is executed, otherwise program execution continues with the statement "tax_rate = tax_val / 100;"

By now you should be asking yourself: "How does the compiler know what statement is associated with the 'if' statement?" The answer of course is quite simple. Let's clear up the question and expand the "if".

The example we just looked at could just as easily have been written as:

```c
if(tax_val >= 10)
    high_tax++;
    tax_rate = tax_val / 100;
```

This is confusing to the programmer, but not to the compiler. When the "if" statement is encountered, the next sequential statement is the only one that is associated with it. Therefore, only "high_tax++;" is subject to conditional execution. The statement "tax_rate = tax_val / 100;"
"/ 100;" will be executed no matter what the result of the "if" test is.

This brings up the question of how do we provide for the execution of several statements after the "if" statement? Let's take a look.

If it is desired to have a group of statement's execution controlled by an "if" statement, then you must use braces "{}" to form a "block" of one or more statements to be conditionally executed. For example:

```c
if(test_expression)
{
    first_statement;
    second_statement;
    ...
    last_statement;
}
```

next_sequential_statement;

Which of the following is used to "block" statements into a group to be conditionally executed?

A. ()
B. {}
C. { }
D. ; ;

Correct.

An option to the "if" statement is the use of an "else".

I will use the same example as before to illustrate the structure and use of the "if-else" control structure.

```c
if(tax_val >= 10)
    high_tax++;
else
    low_tax++;`
tax_rate = tax_val / 100;

Here, the expression "tax_val >= 10" is tested. If the value of the
"tax_val" is greater than or equal to 10, then "high_tax++" is execu-
ted, otherwise "low_tax++" is executed before execution continues with
the statement "tax_rate = tax_val / 100;"

Of course you may use a "block" of statements after either or both the
"if" or "else" parts of the control structure. For example:

if(test_expression)
{
    statement_1;
    statement_2;
}
else
{
    alt_statement_1;
    alt_statement_2;
    statement_3;
}
next_sequential_statement;

It is often the case that you may need to test more than one expres-
sion within an "if-else" structure. This may be done by using what
is called a multi-way decision structure. I will show you one way
to do this using the "if-else" structure now, and later we will see
another way using the "switch" structure. Using "if-else" structure:

if(tax_val >= 10)
    high_tax++;
else if(tax_val <=5)
    low_tax++;
else
    medium_tax++;

Using this structure, one of the
variables: "high_tax", "low_tax",
or "medium_tax" will get incremented
depending on the value of "tax_val".
If you didn’t want to keep track of
"medium_tax", you could leave off
the last else and its statement.

When using the "if-else" control structure, you are limited to only one
executable statement for each part of the structure. (True or False)

Right. "Blocks" of statements can be defined by the use of braces "{\}".
Wrong. "Blocks" of statements can be defined by the use of braces "{\}".
Another capability of the "if-else" structure is being able to "nest" other "if" or "if-else" structures within the original "if-else". For example:

```plaintext
if(test_exp_1)
  if(test_exp_2)
    statement_one;
  else
    alt_statement_one;
else
  statement_two;
next_seq_statement;
```

In this structure, if "test_exp_1" is true then "test_exp_2" is checked and if found true, then "statement_one" is executed if however, "test_exp_2" is false, then the "alt_statement_one" is executed. If the "test_exp_1" was found to be false, then only "statement_two" would be executed.

Note: True is any "non zero" value and false is a "zero" value. Also, "blocks" of statements can be used in the structure.

Caution must be exercised when nesting "if-else" structures. Remember, the "else" part of the "if-else" structure is optional. Thus, it is fairly easy to have an "else" apply to the wrong "if" statement. Let's take a look at an example to show how this can happen.

For our example, let's say we want to check an expression and if it is true, then we want to check a second expression and if it is true, then we want to execute a statement, but if the second expression is false, we don't want any statement executed. If however, our first expression is false, then we want to execute a different statement. How would we code such a thing? Well, let's give it a try.

At first glance the following seems to do what was described.

```plaintext
if(test_exp_1)
  if(test_exp_2)
    statement_one;
  else
    statement_two;
```

Even though I indented the code to look like the "else" goes with the first "if", it really goes with the last "if" that doesn't have an "else". Thus, the above code doesn't solve the problem as I stated it.

In order to solve the stated problem, we must use braces to force
program execution.

Compare the code I gave before (left) to the correct code (right).

```c
if(test_exp_1)
  if(test_exp_2)
    statement_one;
  else
    statement_two;
else
  statement_two;
```

As you can see, the execution of the code is greatly affected by the placement of the braces in the "if-else" control structure.

As you can see, the execution of the code is greatly affected by the placement of the braces in the "if-else" control structure.

Given:
```c
if(x > 0)
  if(x > 10)
    x_large = 1;
  else
    x_small = 1;
else
  if(x == 0)
    x_zero = 1;
```

Which of the following would be true if x = -1?

A x_large would be set to 1
B x_small would be set to 1
C x_zero would be set to 1
D none of the above
E A, B, and C would be true

Very good.

Wrong. All expressions would be false, therefore no statements would be executed.

### Switch Statement ###

We saw earlier that one way to do multi-way decisions was with the use of several "if-else" statements linked together.

A common use of such a structure is when you test a variable and depending on its value (as compared to a constant) a statement or group of statements is executed. For example:

```c
if(test_var == 10)
  statement_to_be_executed;
else if (test_var == 15)
  alt1_statement_to_be_executed;
else if (test_var == 20)
  alt2_statement_to_be_executed;
```
else
   default_statement_to_be_executed;

In the example, we saw how to use the "if-else" structure to accomplish the testing of one variable and execution of different statements depending on the value of the variable.

Well, in C we have another way to accomplish the same thing. We can use the "switch" statement. In the "switch" statement each constant value we wish to test the variable against is labeled with the keyword "case". The last statement (following the last "else" in our example) is labeled with the keyword "default".

Let's take a look at our example again, but this time we will use the "switch" statement structure.

switch(test_var) {
    case 10:
        statement_to_be_executed;
        break;
    case 15:
        alt1_statement_to_be_executed;
        break;
    case 20:
        alt2_statement_to_be_executed;
        break;
    default:
        default_statement_to_be_executed;
        break;
}

Essentially, the "switch" is just a special case of the "if-else" structure, and its use is really just "programmer preference". (True or False)

Right. You can do the same thing using the "if-else" structure.
Wrong. You can do the same thing using the "if-else" structure.

In this topic we have looked at the "if" statement, the "if-else" structure, nesting of the "if-else" structure, and the "switch" statement.
We have seen many examples of what these statements and structures look like, and how they are used.

In the next topic area I will describe and show examples of loop statements and structures.

See you there!

*** This concludes this topic area. ***
loop_var = 0;
while (loop_var == 0) {
    if (sum < 10)
        sum += 2;
    else
        loop_var++;
}

When the "while" is encountered, the test expression is checked and found to be "true", so the loop body is then executed. Execution of the loop body will continue until the loop control expression is no longer true. That will occur, in this example, after 6 iterations.

If the loop control expression is "false" the first time it is checked, then the loop body will be executed only once before program control drops to the next sequential program statement after the "while" loop. (True or False)

That's right. The loop body will be skipped entirely.

Wrong. The loop body will be skipped entirely.

The "for" loop is a three part control structure. The first part is the loop control initialize expression, the second part is the loop control test expression, and the third part is the loop control increment expression.

The loop control initialize expression is a expression that is evaluated once and can serve to initialize variables used within the loop body. The loop control test expression is tested at the beginning of the loop and after execution of the body. Again, the loop control expression is "true" whenever it is "non zero" and "false" when it is "zero". Execution of the body will continue until the control expression is "false". If the expression is "false" the first time, then program control will drop to the next sequential program statement. The loop control increment expression is evaluated after execution of the loop body.

The structure of the "for" loop looks like this:

for (initialize_exp; test_exp; increment_exp)
    statement_to_be_executed;

Again, the braces can be used to define a "block" of statements. Such as:
for (loop_var = 0; loop_var < 50; loop_var++) {
    first_statement;
    next_statement;
    last_statement;
}

Here is an example using the "for" loop control statement:
for (i = 0; i < 20; i++)
    if((i % 2) == 0)
        printf("i value is even");
    else
        printf("i value is odd");

When the "for" is encountered, the loop control initialize expression
is executed setting i equal to zero. Next the loop control test ex-
pression is checked and found to be "true", so the loop body is then
executed. After execution of the loop body the loop control increnent
expression is executed settint i equal to i plus one. The loop control
test expression is then checked again. The execution of the loop body
will continue until the loop control expression is no longer "true".

Which of the following is "not" a part of the "for" loop control structure?
A initialize expression
B test expression
C terminate expression
D increment expression

Correct. Keep up the good work.

As I mentioned before, loop structures serve basically the same purpose
and can usually be accomplished by using one such structure. We have
looked at both "while" and "for" loops so far. Let's compare the struc-
ture of these two loop types.

The "while" structure:

init_exp;
while (test_exp) {
    statement_to_be_executed;
}

The "for" structure:

for (init_exp; test_exp; incr_exp) {
    statement_to_be_executed;
}
Which of these two structures you use is up to you, but there are times when one may be more appropriate than the other.

The final loop structure available in C is the "do-while".

The "do-while" loop is a two part control structure just like the "do" loop. The basic difference between the "do" loop and the "do-while" loop is that the first part of the "do-while" is the executable body, and the second part is the loop control expression. This is just the opposite of the "do" loop control structure.

The loop body will be executed once, before the loop control expression is tested at the end of the loop. If the loop control expression is "true" then the loop body will be executed again. Execution of the loop body will continue until the loop control expression is "false". The biggest difference, I'm sure you have noticed, is that the loop body will be executed at least one time before program control drops to the next sequential program statement.

The major difference between the "while" loop and the "do-while" loop is that the "do-while" will always be executed at least once whereas the "while" loop may be skipped altogether if the loop control expression is "false".

Right.
Wrong. That is a true statement.

In this topic we have looked at the "while", "for", and "do-while" loops.

We have seen many examples of what these statements and structures look like, and how they are used.

In the next topic area I will describe and show examples of the "break" and "continue" statements.

Hope I see you there!

*** This concludes this topic area. ***

*** Break Statement ***

The "break" statement is used to terminate a "while", "for", or the "do-while" loop before the loop control expression becomes "false". It is also used in the "switch" control statement to prevent further statement execution after a "case" has been found that satisfies the switch.

When a "break" statement is encountered, it is executed and the loop or case in which it is located is terminated immediately. Program control then passes to the next sequential statement following the loop or switch.

I will show you how this looks in each of the loop structures as well as the "switch" structure.

But first I want to be sure you want to see these examples.

Do you want to see examples of how the "break" statement is used? (Yes or No)

Y

OK. Here we go.
exit = 0;
while (exit == 0) {
    scanf("%d", &in_int);
    if(in_int < 0)
        break;
    else
        sum += in_int;
    if(sum > 100)
        exit++;
}

Without getting into details of how the "scanf" statement works or where you would use this section of code, this example shows how the "break" statement can be used to terminate the "while" loop before the loop control statement becomes "false". If the variable named "in_int" ever becomes a negative number, the "break" will be executed and program execution will continue with the next sequential statement after the loop.

Break Statement Example #2: "For" loop

The following is an example of how the "break" statement can be used in the "for" loop.

for (i=0; i<=10; i++) {
    in_char = getchar();
    if(in_char == '.')
        break;
    last_name[i] = in_char;
}

Here, the loop will be terminated if "in_char" becomes a period (.) and program execution will, once again, continue with the next sequential statement after the loop. Note: We will cover "arrays" in lesson 4 and "input & output" in lesson 6.

Break Statement Example #3: "Do-While" loop

The following is an example of how the "break" statement can be used in the "do-while" loop.

count = 0;
do {
    count++;
    if(count > 10)
        break;
    avg_num = (total / tot_num);
    scanf("%d", &in_int);
    tot_num++;
    total += in_int;
} while (avg_num < 70);

In this example, there are really two loop control expressions. The loop would be terminated if the value of "count" becomes greater than 10, or if variable "avg_num" ever exceeds the value of 69. Since the "do-while" is executed before the loop control expression is tested, the "break" statement could be used to control the loop's execution the first time through.

Break Statement Example #4: "Switch" statement

C - 64
The following is an example of how the "break" statement is used in the "switch" statement.

```c
switch(temp) {
    case 70:
        nice++;
        break;
    case 80:
        hot++;
        break;
    case 90:
        cool++;
        break;
    case 50:
        if in our example the value of "temp" is 70,
        there is no need to check any "cases" after
        the execution of the statement "nice++;".
}
```

Which of the following will the "break" statement "not" work with?

A. "while" loop
B. "for" loop
C. "switch" statement
D. "if-else" statement
E. "do-while" loop

Right you are. The "if-else" works the same as the "switch" without the use of the "break" statement.

Which of the following will the "break" statement "not" work with?

A. "while" loop
B. "for" loop
C. "switch" statement
D. "if-else" statement
E. "do-while" loop

Wrong. The "if-else" works the same as the "switch" without the use of the "break" statement.

The "continue" statement is used within a loop structure in order to force the loop's next iteration. The "continue" is used with the "while", "for", and "do-while" loops, but NOT with the "switch" statement.

When you use the "continue" in the "while" and "do-while" loops, it forces the immediate evaluation of the "loop control expression".

When you use the "continue" in the "for" loop, it executes the "loop control increment expression" and then the "loop control expression" is evaluated.

Let's take a look at an example.
The following is an example of the use of the "continue" statement in a "for" loop.

```c
for (i=0; i<max_i; i++) {
    if(name_area[i] != '
')
        continue;
    num_found++;
}
```

In this example the "continue" statement causes the loop to be executed until a "space" is encountered or the "loop control test expression" becomes "false". Once a space is found, "num_found" is incremented, the "loop control increment expression" is executed, and the "loop control test expression" is evaluated. Execution will continue in this fashion until the "loop control test expression" becomes "false".

---

The use of the "continue" is only effective in the loop control structures of "while", "for", and "do-while". (True or False)

- Right. It can be used in a "switch", but only if the switch is inside of a loop structure, in which case it would cause the next iteration of the loop structure.
- Wrong. It can be used in a "switch", but only if the switch is inside of a loop structure, in which case it would cause the next iteration of the loop structure.

---

In this topic we have looked at the "break" and "continue" statements. I have presented you the opportunity to see many examples of how the "break" statement is used in the three different loop structures as well as the "switch" statement. You also saw an example of how the "continue" statement can be used within a "loop" structure.

In the next topic area I will describe and show examples of the "goto" and "label" statements.

Hope I see you there!

---

This concludes this topic area.
engineering community of experts. Although most languages provide for
the use of "goto", it is highly discouraged. Most instances of the
statement can be eliminated by careful software development. This is
especially true in a language such as C.

Even though use of the statement is discouraged, it is a part of the
language and therefore I will give a brief description of how it is
used.

In order to use the "goto" statement, you must have some way of identi-
ing where to "goto" to. In other languages such as BASIC or Fortran,
this is done by using statement numbers. C doesn't use statement num-
bers but instead uses "labels".

A label is declared in a function by using the following form:

label_name:

When naming a "label", follow the same rules that you use when naming
a variable.

The "goto" statement is used to transfer program control to some point
within a function other than the next sequential statement. The point
MUST be a labeled point in the same function.

The most common use of the "goto" statement is to terminate execution
of a deep nested loop structure. As we learned in the last topic area,
we can use the "break" statement to terminate a loop but it will only
terminate the inner-most loop (the one it is physically in).

A "goto" statement has the following form: goto label_name;

Note: "goto" is one word. The use of: go to label_name; will cause
a compile error.

The following two sections of code provide an example of how the "goto"
statement is used in conjunction with a label and how to write the same
section without using a "goto" statement.

Code with the "goto" & "label"  ;  Code without using the "goto"
-----------------------------------------------
in_out() {}  ;  in_out() {}
char c;
begin:
c = getchar();
if(c!="\n") {
    printf("%c",c);
    goto begin;
} return;
do {
    c = getchar();
    if(c!="\n") {
        printf("%c",c);
    } while (c!="\n" );
} return;

You can only use the "goto" statement to transfer program control to a label within the function where the "goto" is located. (True or False)

Right.

Wrong. You can not transfer control to any other part of the program using the "goto" statement.

*** Lesson Three Summary ***

Well, we have come to the end of another lesson. If you have seen the four subject topics in this lesson, you should now be ready to take the final test. If you feel that you don't understand something well enough to pass the test, please retake the topic that is giving you problems.

Topic 1 described the "if", "if-else", "nesting", and "switch".
Topic 2 described the "while", "for", and "do-while" loops.
Topic 3 described the "break" and "continue" statements.
Topic 4 described the "label" and "goto" statements.

Good Luck on the test.

Welcome to the final test of lesson three. This test consists of ten questions over material presented in the previous four topic areas.
In order to successfully complete this lesson, you must achieve a minimum score of 70% (seven out of ten questions correct).
If you miss a question, the correct answer will not be shown. It is up to you to research the correct answer.

Well, enough said. Let's get on with it. Good luck!

Which one of the following is "not" one of the control statements that was covered in this lesson?
53A if
53B if-else
53C switch
53D+ while
54 Right. (1,100)
54 B:910
55 ABC Wrong. (1,100)
55 B:910
55 E "E" was not one of your choices.
55 B:905
51 Frame 910 QP
52. Braces "{" are used to form a "block" of one or more statements to be
52 conditionally executed. (True or False)
53Y
54 Right. (1,120)
54 B:915
55 Wrong. (1,120)
55 B:915
51 Frame 915 QM
523. Since the "else" part of the "if-else" control structure is optional,
52 care must be taken to prevent which of the following from occurring?
53A having the "else" statement skipped.
53B+ having the "else" applied to the wrong "if" statement.
53C having an "else" applied to two "if" statements.
53D having the "if" statement executed before the "else".
54 Right. (1,150)
54 B:920
55 BCD Wrong. (1,150)
55 B:920
55 E "E" was not one of your choices.
55 B:915
51 Frame 920 QP
524. Essentially, the "switch" is just a special case of the "if-else"
52 structure, and its use is really just "programmer preference".
52 (True or False)
53Y
53 B:930
54 Right. (2,320)
54 B:925
55 Wrong. (2,320)
55 B:925
51 Frame 925 QM
525. If the "loop control expression" in the "while" loop is "false" the first
52 time it is checked, which of the following statements would be true?
53A The loop body would be executed one time only.
53B The loop would be executed until the control expression becomes "true".

C - 69
The loop body would be skipped altogether.
The loop would become an infinite loop.
Right. (2,305)
Wrong. (2,305)
"E" was not one of your choices.
"E" was not one of your choices.
Right. (2,320)
Wrong. (2,320)
Wrong. (2,345)
Wrong. (2,345)
Wrong. (2,350)
Wrong. (2,350)
"E" was not one of your choices.
The major difference between the "while" loop and the "do-while" loop is that the "do-while" will always be executed at least once whereas the "while" loop may be skipped altogether if the loop control expression is "false". (True or False)
Right. (3,500)
Wrong. (3,500)
Wrong. (2,305)
Wrong. (2,305)
Wrong. (2,305)
Wrong. (2,305)
Wrong. (2,305)
Correctly used with:
for loop
"do-while" loop
switch
while loop
Right. (3,535)

Wrong. (3,535)

"E" was not one of your choices.

Wrong. (4,710)

Wrong. (4,710)

"E" was not one of your choices.

This marks the end of lesson number three. I hope that it was of some benefit to you. I am looking forward to seeing you in lesson number four. I hope that you didn’t have too much trouble with the material presented in this lesson. If you did, please voice your comments to your training monitor who will in turn contact the CAI Plans Branch at Keesler AFB, MS.

Well, let’s take a look at how you did with the test ...
THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INFORMATION ON ARRAYS, POINTERS, AND ADDRESS ARITHMETIC USED IN C PROGRAMMING.

THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.

The Lesson Breakdown Is As Follows:

Topic 1: Introducing Arrays - This topic introduces the declaration, initialization, and use of arrays. (Approx. time = 15 min.)

Topic 2: Introducing Pointers - This topic introduces the declaration and use of pointers. (Approx. time = 15 min.)

Topic 3: Working with Pointers I - This topic is the first of two that covers how to work with pointers. Emphasis is on how pointers are passed to functions. (Approx. time = 10 min.)

Lesson Breakdown Continued:

Topic 4: Working with Pointers II - This topic is the second of two that covers how to work with pointers. Emphasis is on how pointers are used in conjunction with arrays and the use of address arithmetic. (Approx. time = 10 min.)
# Topic 5: Lesson 4 Test - This is the lesson test over items that have been presented in the previous four lesson topics. (Approx. time = 5 min.)

# TOTAL LESSON TIME IS APPROXIMATELY 55 MINUTES.

I hope that you enjoy it!

*************************************************************

SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:

*************************************************************

<table>
<thead>
<tr>
<th>STATUS</th>
<th>TOPIC #</th>
<th>TOPIC TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>@</td>
<td>1</td>
<td>Introducing Arrays</td>
</tr>
<tr>
<td>@</td>
<td>2</td>
<td>Introducing Pointers</td>
</tr>
<tr>
<td>@</td>
<td>3</td>
<td>Working with Pointers I</td>
</tr>
<tr>
<td>@</td>
<td>4</td>
<td>Working with Pointers II</td>
</tr>
<tr>
<td>@</td>
<td>5</td>
<td>Test Over Lesson 4</td>
</tr>
</tbody>
</table>

NOTE: A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.

*************************************************************

11Frame 100 T Introducing Arrays
12 *** Introduction ***
12
12 An "array" is a group of contiguously stored related variables.
12
12 In this topic area we will take a look at the basic use of arrays and some advanced concepts involving arrays.
12
12 To be more specific, we will be looking at: one dimensional arrays, multidimensional arrays, and array initialization.
12
12 Let's get started.
13B:105
11Frame 105 T
12 *** One Dimensional Arrays ***
12
12 The language C does not have a "string" variable type, therefore it uses an array of characters to accomplish the same thing. If you
think of a string of characters such as a sentence. How would you store it in your program? Well, the answer of course is to use an array of characters.

The structure of the basic one dimensional character array declaration statement is:

```c
char var_name[n]; where "n" is the number of characters in the array.
```

Now comes the tricky part. The individual characters in the array are called the "elements" of the array. Accessing these elements is a very common procedure in programming. Let's look at an example that uses an array and see how this is done.

For our example, let's say we want to store the word Payment. The first thing we must do is decide on the size of the array that will hold this word. This can be done by counting the number of characters in the word. So, let's see... I count 8.

At first glance it looks like I made a mistake in counting the characters in Payment. This is not the case. In C the first element of an array is stored in array position 0 (zero), and the last (string) array position element is always a null character (\0). So, using the following statement to declare our word as a character string constant...

```c
char ex_word[8] = "Payment";
```

the array will be filled as follows:

```
char ex_word[0] = P
ex_word[1] = a
ex_word[2] = y
ex_word[3] = m
ex_word[4] = e
ex_word[5] = n
ex_word[6] = t
ex_word[7] = \0
```

The "null character" stored at the end of a string array is put there automatically by the C compiler. All you have to worry about is to leave room for it in your array. What if you don't want to worry about such things? Well, there is a way to get around counting the number of characters in a string constant and then adding one for the null character. Let's take a look.
11Frame 120 T
12 * One Dimensional Arrays Continued *
12
12 Using the statement: char ex_word[] = "Payment"; will accomplish the
12 same thing as the example we just looked at. Namely, an array consis-
12 ting of eight elements will be declared and filled by the compiler.
12
12 The way in which the individual elements in an array are accessed is
12 by referencing the element using an index. In our example an index of
12 4 would look like this: ex_word[4] and yield the character e.
12
12 Our discussion thus far has only dealt with the C character type. The
12 use of arrays is by no means restricted to this C variable type. Here
12 are a couple examples of arrays of other variable types:
12
12 int ex_ints[35]; This is an array of integers (36 of them).
12
12 float ex_floats[67]; An array of floating point reals (68 of them).
13B:125
11Frame 125 QM
12
12 Given the character array declaration: char example[] = "Example";
12 Which of the following is the correct number for "n"?
13A 10
13B 9
13C 8
13D 7
14 Right. Seven characters plus the "null character", therefore 8.
14 B:130
15ABD Wrong. There are seven characters plus the "null character",
15 example[0] thru example[7], therefore the correct answer is 8 ("C").
15 B:130
11Frame 130 T
12 ** Multidimensional Arrays **
12
12 As we have seen, a one dimensional array is declared using a statement
12 such as char ex_word[8];. The dimension of this array is seen as a
12 list of characters running from ex_word[0] to ex_word[7].
12
12 A two dimensional array can be thought of as a table consisting of rows
12 and columns. The way in which a two dimensional array is declared is
12 as follows:
12
12 int ex_int[n][m]; where "n" is the number of rows
12 and "m" is the number of columns.
12
12 Let's look at an example.
13B:135
11Frame 135 T
12 * Multidimensional Arrays Continued *
If we want to store the test scores for a class of 5 students who have each taken 4 tests, we could do it like this:

```c
int scores[5][4] = {
    {75,80,70,95},
    {85,85,90,95},
    {60,90,80,90},
    {70,80,90,90},
    {75,85,95,85}
};
```

This form is very representative of how the table would look. How these numbers are stored is as follows: scores[0][0] = 75, scores[0][1] = 80, scores[0][2] = 70, and scores[0][3] = 95. You then increment the first index and continue: scores[1][0] = 85 ... scores[4][3] = 85.

In our example, we defined an array with 5 rows and 4 columns. We also filled the array with test scores. Of course these test scores are useless unless we have defined the student that each row represents. This can be done several ways, but I would define a symbolic constant for each student. Such as:

```c
#define Jones 0
#define Smith 1
#define Brown 2
#define Green 3
#define White 4
```

Now if you want to find out what Brown got on his third test you could use the statement: Brown_3 = scores[Brown,2]; This will retrieve the score stored in array position scores[2][2], which was 80.

A good way I've found to get used to arrays is to experiment with them.

As you might have deduced by now, you can define arrays of more than two dimensions. All that needs to be done is add more brackets ([]) after the array name.

For example:

```c
int four_D_array[5][10][5][20];
```

Don't ask me to give you a visual picture of such a thing, but I can tell you that there are 5000 integer storage locations allocated by such a declaration (5 x 10 x 5 x 20 = 5000).
Which of the following is the value stored in position array[1][2]?

A 80
B 60
C +90
D 85
E 70

Very good.

A B:155
B DABDE No. Answer "C" is the correct one.
C B:155

Array Initialization

We have already seen some of the ways in which arrays are initialized.
When I gave an example of a one dimensional character array I used the statement:

char ex_word[8] = "Payment";

That is one way to initialize the character array, another way would be:

char ex_word[] = "Payment";

Yet another way would be:

char ex_word[] = {'P', 'a', 'y', 'm', 'e', 'n', 't','\0'};

All the above are correct if the array is a "global" array.

Array Initialization Continued

You may NOT initialize arrays that are "automatic". This means any arrays that are contained within a function. In order to initialize an array within a function it must be declared as "static". The way this is done is by use of the keyword "static".

For example:

This initialization is wrong. ! This is the correct way.

```
sample() {
    char array[] = "Example";
    .
    .
    .
    .
    .
    .
    .
}
```

This initialization is wrong. ! This is the correct way.

```
sample() {
    static char array[] = "Example";
    .
    .
    .
    .
    .
    .
    .
}
```
When initializing arrays other than character arrays, the initializing is accomplished with values enclosed in braces. For example:

A one dimensional global integer array can be initialized using:

```c
int array[5] = {24,67,82,90,41};
```

Or, if all values of the array are being specified, the dimension can be left out, as in:

```c
int array[] = {24,67,82,90,41};
```

Again, if the array is local to a function and needs to be initialized, use the keyword "static".

```c
int scores[5][4] = {
    {75,80,70,95},
    {85,85,90,95},
    {60,90,80,90},
    {70,80,90,90},
    {75,85,95,85}
};
```

If any of the values are missing, then the array value will be stored as 0 (zero). Note: If values are missing, than dimensions must be specified. Of course "static" must be used for local function arrays that you want to initialize.

The integer array initialization: `int array[] = {2,4,6,8};` is valid for a one dimensional integer array having 5 elements. (True or False)

**Right.** If you intend for the array to have 5 elements then either 5 values must be give in the list or a dimension of 5 must be explicitly stated.

Wrong. If you intend for the array to have 5 elements then either 5 values must be give in the list or a dimension of 5 must be explicitly stated.

**In this topic we have looked at "one dimensional" and "multidimensional" arrays. We have also seen how to initialize these arrays.**
look like, and how they are used.

In the next topic area I will describe pointers and give a few examples of their use.

See you there!

*** This concludes this topic area. ***

---

** Introducing Pointers

A "pointer" is a variable that contains the address of where some other variable resides in memory.

In this topic area I will describe how pointers are declared and used within a C program.

Since pointers can be very confusing to someone who has not seen them before, I will restrict my discussion to elementary concepts and leave their more advanced uses for your research.

Let's get started.

---

** Pointers

In the declaration: int var_one = 500; a storage location is set aside in memory for an integer variable and the value of 500 is stored in that memory location. That memory location also has a memory address.

In C, you can determine the memory address by the use of the unary operator &.

The way that you would assign a pointer variable to the memory location where "var_one" is located is: point_v1 = &var_one; this assigns the address of the variable "var_one" to the variable "point_v1".

Note: Pointer names follow the same rules as other variable types and must be declared as the same type of the variable being pointed to (as we'll see later).

---

** Pointers Continued

That's fine. Now we know how to find out the memory address of a variable, but what good is it?

It would be nice if we could now find out the value stored at the address pointed to by our pointer. C just happens to have a special
operator that allows us to do just that.

In C, you can determine the value stored at an address pointed to by a pointer by the use of the unary operator `*`.

The way that you would use this operator to find the value stored at a pointed to address is: `var1_val = *point_v1;` this statement assigns the value stored at the memory location pointed to by "point_v1" to the variable "var1_val". Which, in our example, would be 500.

The two unary operators used when working with pointers are the _____ and the _____.

A. `#` and `&`
B. `&` and `*`
C. `$` and `&`
D. `$` and `#`
E. `#` and `-`

ACDE Wrong. Answer "B" is the correct response.

In order for pointers to be used in a C program, you must declare a pointer variable before you can use it. The type of the pointer variable must be the same as the variable that it is to point to.
In our example, the statement: `point_v1 = &var_one;` must be preceded by the declaration: `int *point_v1;` which states that the value to be pointed to by "point_v1" is of type "int".

Pointers to other types of variables are declared in the same way. For example:

```c
char *char_point; declares the pointer variable "char_point" which is to point to a variable of type "char".
```

The declaration: `float *var_point;` declares the pointer variable "var_point" to be of type "float".

Very good. It declares the pointer variable "var_point" which "points" to a variable of type "float".

No. It declares the pointer variable "var_point" which will "point" to a variable of type "float".

*** Pointer Facts ***

Pointers can be used in expressions. For example:

```c
answer = *point + 35; adds 35 to the value pointed to by "point" and stores the result in variable "answer".
```

```c
*p_1 = *p_2 * 5; multiplies the value pointed to by "p_2" by 5 and stores the result in the variable pointed to by "p_1".
```

```c
p_one = p_two; will make "p_one" point to the same variable that "p_two" points to if both "p_one" and "p_two" are declared to point to the same variable type.
```

(i.e. int *p_one, *p_two;)

*** Topic Review ***

In this topic we have looked at pointer declaration and a few elementary examples of how they are used.

The rest of this lesson will discuss some other uses of pointers in C programming.

In the next topic area (3) I will describe and show examples of how to pass pointers as function arguments. In topic area four I will discuss the use of pointers in conjunction with arrays and explain how to do address arithmetic.

Hope I see you there!
*** This concludes this topic area. ***

This concludes this topic area.

In the last topic area we saw that a "pointer" is actually a variable that contains the address of where some other variable resides in memory.

In this topic area I will describe how pointers are passed to functions, a rationale for doing it, and a few examples.

Let's get started!

We have seen two methods of passing arguments to a function, although I have not explicitly named these methods. Now is as good a time as any to do so. They are: "Call by value" and "Call by reference".

The main difference in the two is that the actual value stored in a variable can only be changed by using the "Call by reference" method of argument passing. Let's look at a couple of examples to help make this clear.

Let's say we have a C program that has two functions "main" and "add". The "main" function calls the "add" function and passes it two variables "x" and "y". The "add" function takes the two arguments and adds 50 to the first (x) and 75 to the second (y). The "main" function then prints out the two variables "x" and "y".

Let's see what these two functions might look like.

This is a clear example of the "Call by value" method. Even though I called the two variables the same name in both of the functions, each function has its own copy of the variables. Hence, the actual values of "x" and "y" in "main" are never changed by the function "add". This will result in "10" and "30" being printed by the "main" function. One way around this problem is to make "x" and "y" global to both functions. The preferred method is to use "pointers" as we will see shortly.

To introduce us to the concept used in passing pointers, let's look at another example.
For this example let's say we have two functions "main" and "init". The "main" function declares an array called "line" to be a sequence of 80 characters. The "main" function calls the "init" function and passes it the array to be initialized to blanks.

```
int(b_line) char b_line[];
{
    for (i=0; i<80; i++)
        b_line[i] = ' ';
}
main()
{
    char line[80];
    init(line);
}
```

This is a clear example of the "Call by reference" method. Although I called the array \( b\) \{ line \[ \] \}; this is because the function "main" actually passes the address of where the array "line" begins in memory to the function "init".

```
main() {
    char line[80];
    init(line);
}
```

This "Call by reference" only works in the case of arrays. Before we look at pointer passing, let me ask you a quick question.

```
Right. You have been paying close attention.
Wrong. I hope you aren't falling asleep on me.
```

We've seen in another lesson that a called function can only return one value to the calling function. Thus, only one value of the calling function is truly changed. This of course precludes the use of global variables by the functions in question.

```
If it is necessary for the called function to change more than one variable of the calling function, then the preferred method is to use addresses or pointers as passed arguments.
```

There are three ways in which to accomplish the task introduced above.

```
1. Pass the address of the variable.
2. Pass a pointer to the variable.
3. Pass an array name.
```

If we have a function that is to be called and its "function" is to change two variables (as in our first example), we can set up the function to receive pointers as its arguments as follows: C - 83
In this example I have identified the variables "px" and "py" to be pointers to variables of type "int". When the function is executed, the values stored in the variables, pointed to by these pointers, will change by "50" and "75" respectively.

Let's look at how we would pass the "addresses" of the variables to this function from our "main" function.

One way we have identified as being a way to pass a pointer to a function is by passing the "address". The following illustrates this method.

```
main() {
    int x, y, *px, *py;
    x = 10;
    y = 30;
    px = &x;
    py = &y;
    add(px, py);
    printf("\n%d %d", x, y);
}
```

Now let's look at another way to pass pointers from the calling function to the called function.

An alternate way of passing pointer information is to pass the pointer itself. The following illustrates this method.

```
main() {
    int x, y, *px, *py;
    px = &x;
    py = &y;
    add(px, py);
    printf("\n%d %d", x, y);
}
```

The third method of passing pointer information (pass an array name) was already discussed.

Which of the following is "not" one of the ways in which to pass information that will allow the value of a variable to be changed by a called function?

A. Pass a pointer to the variable.
Pass an array name.

Pass the variable name.

Pass the address of the variable.

Very good.

No. That is one of the ways "to" do it. The correct response is "C".

"E" was not a given choice. Please try again.

*** Topic Review ***

In this topic area we have looked at the "Call by reference" and "Call by value" methods of argument passing as well as how to pass pointers as function arguments.

We have seen several examples to help illustrate all of these methods.

In the next topic area I will describe the use of pointers in conjunction with arrays and explain how to use address arithmetic.

Hope to see you there!

*** This concludes this topic area. ***
between functions by just giving the array name. For example:

```
init(line); This calls the function "init" and passes the array "line".
```

What actually happens is the C compiler passes the address of the "0"th element of the array. So in essence, a pointer to the beginning of the array is passed ("line" being the pointer).

```
char *p_line; This identifies "p_line" as a pointer to a variable of type "char".
p_line = &line[0]; This assigns the address of the "0"th element of array "line" to the pointer variable "p_line".
init(p_line); This calls the function "init" and passes the address of the starting location of array "line".
```

Once the above declarations have been made, the two expressions:

```
"line" and "p_line" are interchangeable.
```

### Question:

If you have the declaration: `char line[10];` which of the following statements will assign the address of the "0"th element to a pointer variable that has been declared using the statement: `char *p_line;`?

- A. `*p_line = line[0];`
- B. `p_line = line[0];`
- C. `*p_line = &line[0];`
- D. `p_line = &line[0];`

**Answer:**

D. `p_line = &line[0];` is the correct response.

### Answer:

Correct response: D. `p_line = &line[0];`

Wrong: B. `p_line = line[0];` is not a given choice. Please try again.
plish the same effect. Note: It is also legal to use the notation "p_line[0]", but we will avoid this to cut down on the confusion.

Now that we have pointer access to the array, we can manipulate the pointer to point to any of the array elements by use of address arithmetic.

The most common use of address arithmetic is through the use of the increment, decrement, addition, and subtraction operators.

The operation must involve a pointer and an integer with the exception of the subtraction operator (subtraction/comparison of two pointers is allowed).

The use of "relational" operators is legal as long as the pointers point to members of the same array. The use of the "operational assignment" operators "+=" and "-=" are also legal.

Let's look at an example of how to use some of these operators.

When we first started this topic area I used the declaration statement: char line[] = "This is an example"; to declare and initialize the array "line".

Using the declarations: char *p_line; and p_line = &line[0]; we established a pointer to the "0"th element of array "line".

We also saw that the expressions "line[0]" and "p_line" are equivalent.

Both would return a value of T if used in a statement such as:

\[
\text{char_val = line[0]; OR char_val = *p_line;}
\]

We can move forward and backward in the array by using our pointer and the legal operators mentioned before.

If we want to move one element forward in the array we can use the increment operator (++), the addition operator (+), or the operational assignment operator (+=).

For example: p_line++ will make the pointer point to the next sequential element in the array. Likewise, p_line = p_line + 1; and p_line += 1; will have the same effect.
In general, it can now be said that if "p_line" is a pointer and "i" is an integer, then \( p_line += i \) will increment "p_line" by "i" thus making "p_line" point to an element "i" elements beyond its present location. Decrementing is done in a similar fashion.

Given that "pa_val", "pb_val", and pc_val are pointers. Which of the following statements is "not" a "legal" address arithmetic operation?

A: \( pc\_val = pb\_val + pa\_val; \)

B: \( pc\_val = pb\_val - pa\_val; \)

C: \( pa\_val += (pb\_val += pc\_val); \)

D: \( pa\_val = (pb\_val - pc\_val); \)

Very good. Addition of two pointers is not allowed.

B: 745

C: Wrong. That is a valid statement involving address arithmetic.

D: 745

E: "E" was not a given choice. Please try again.

B: 740

*** Lesson Four Summary ***

Well, we have come to the end of lesson four. If you have seen the four subject topics in this lesson, you should now be ready to take the final test. If you feel that you don’t understand something well enough to pass the test, please retake the topic that is giving you problems.

Topic 1 gave an introduction to one and multidimensional arrays.

Topic 2 gave an introduction to pointers and their use.

Topic 3 gave a description of how pointers are passed to functions.

Topic 4 gave a description of pointer use in conjunction with arrays.

Good Luck on the test.

Welcome to the final test of lesson four. This test consists of ten questions over material presented in the previous four topic areas.

In order to successfully complete this lesson, you must achieve a minimum score of 70% (seven out of ten questions correct).

If you miss a question, the correct answer will not be shown. It is up to you to research the correct answer.

Well, enough said. Let's get on with it. Good luck!
In the array declaration: char word[x] = "Sample"; which of the
following is the correct value for "x"?
A 9
B 8
C+ 7
D 6
Right. (1,110)
B:910
ABD Wrong. (1,110)
B:910
E "E" was not one of your choices.
B:905

Given the array declaration: int array[2][4][6]; how many integer
storage locations are allocated?
A 12
B 24
C 36
D 48
Right. (1,145)
B:915
ABC Wrong. (1,145)
B:915
E "E" was not one of your choices.
B:910

The integer array initialization: int array[5] = {4,8,12}; is valid
for a one dimensional integer array having 5 elements. (True or False)
Y
Right. (1,170)
B:920
Wrong. (1,170)
B:920

Which of the following is the unary operator that is used to determine
the memory address of a variable?
@ # % &
53E Right. (2,305)
54 B:925
55 ABCE Wrong. (2,305)
56 B:925
51 Frame 925 QP
525. The declaration: char *char_point; declares the pointer variable
52"char_point" which points to a variable of type "char". (True or False)
53Y
54 Right. (2,325)
54 B:930
55 Wrong. (2,325)
55 B:930
51 Frame 925 QP
526. The "Call by reference" method of argument passing only passes a copy
52of a variable, whereas the "Call by value" method passes the address of
52the argument. (True or False)
53N
54 Right. (3,510-515)
54 B:935
55 Wrong. (3,510-515)
55 B:935
51 Frame 935 QM
527. Given: main () {
52     int x,y,*px,*py;
52     x = y = 0;
52     px = &x;
52     py = &y;
52     change(px,py); }
52
52Which of the following is the method of pointer passing used?
53A Pass a pointer to the variable.
53B Pass an array name.
53C Pass the address of the variable.
53D Pass the variable name.
54 Right. (3,540)
54 B:940
55BCD Wrong. (3,540)
55 B:940
55E "E" was not one of your choices.
55 B:935
51 Frame 940 QM
528. Given the declaration: int array[10]; which of the following state-
52ments will assign the address of the third element to a pointer variable
52that has been declared using the statement: int *p_array; ?
53A *p_array = &array[2];
53B p_array = &array[2];
53C *p_array = array[2];
53D p_array = array[2];

U - 90
54 Right. (4,710)
54 B:945
55ACD Wrong. (4,710)
55 B:945
55E "E" was not one of your choices.
55 B:940
51Frame 945 OP
529. The statement: init(p_var); calls the function "init" and passes the
52address of the variable pointed to by the pointer "p_var", provided the
52pointer was declared using a statement like "int *p_var;". (True of False)
53Y
54 Right. (4,710)
54 B:950
55 Wrong. (4,710)
55 B:950
51Frame 950 OM
5210. Which of the following operators is "not" a legal operator in address
52arithmetic?
53A +
53B -
53C +=
53D --
53E+ /
54 Right. (4,725)
54 B:955
55ABCD Wrong. (4,725)
55 B:955
51Frame 955 T
52 *** End of Lesson Material ***
52
52 This marks the end of lesson number four. I hope that it was of some
52benefit to you. I am looking forward to seeing you in lesson number
52five. I hope that you didn’t have too much trouble with the material
52presented in this lesson. If you did, please voice your comments to
52your training monitor who will in turn contact the CAI Plans Branch
52at Keesler AFB, MS.
52
52 Well, let’s take a look at how you did with the test ...
The Lesson: Structures in C Programming

The Lesson You Are About To Take Contains Information On Structures That Are Used In C Programming.

The Lesson Currently Consists Of Five Topics.

The Lesson Breakdown Is As Follows:

1. Introducing Structures - This topic introduces the idea of structures and two methods of declaring them. (Approx. time = 10 min.)
2. Structures and Arrays - This topic describes the use of structures within structures and arrays of structures. (Approx. time = 5 min.)
3. Structures and Pointers - This topic describes how to use pointers in conjunction with structures. (Approx. time = 5 min.)
4. Structures and Functions - This topic describes how structures are passed between functions. (Approx. time = 5 min.)

C - 92
# Topic 5: Lesson 5 Test - This is the lesson test over items that have
been presented in the previous four lesson topics.
(Approx. time = 5 min.)

TOTAL LESSON TIME IS APPROXIMATELY 30 MINUTES.

I hope that you enjoy it!

*****************************************************************************
** SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING: **
*****************************************************************************

<table>
<thead>
<tr>
<th>STATUS</th>
<th>TOPIC #</th>
<th>TOPIC TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 1</td>
<td>1</td>
<td>Introducing Structures</td>
</tr>
<tr>
<td>+ 2</td>
<td>2</td>
<td>Structures and Arrays</td>
</tr>
<tr>
<td>+ 3</td>
<td>3</td>
<td>Structures and Pointers</td>
</tr>
<tr>
<td>+ 4</td>
<td>4</td>
<td>Structures and Functions</td>
</tr>
<tr>
<td>+ 5</td>
<td>5</td>
<td>Test Over Lesson 5</td>
</tr>
</tbody>
</table>

NOTE: A "STATUS" OF "+" INDICATES TOPIC SUCCESSFULLY COMPLETED.

*****************************************************************************
| Frame 100 T | Introducing Structures |
| 11           | *** Introduction ***    |
| 12           | A "structure" is typically a group of related variables, of possibly |
| 12           | different types, under a single structure name. |
| 12           | In this topic area we will take a look at the concept of a "structure" |
| 12           | and two methods of declaring them. |
| 12           | We will also be discussing how to access the individual members of a |
| 12           | declared structure. We will see several examples of elementary |
| 12           | structures in order to get you introduced to their declaration and |
| 12           | use. |
| 12           | Let's get started. |
| 138:105      |    |
| Frame 105 T  |  |
| 12           | *** Structures ***       |
| 12           |    |

C - 93
Whenever you have a group of related items it is nice to be able to group them in such a way as to give quick and easy access. In C, the way this is done is through the use of "structures".

For example, if you have information about a student at a university, this information might include items such as: Name, Address, Major, GPA, and Advisor. Instead of keeping all this information stored separately we can form a structure with five parts containing the needed information.

Let's take a look at one way to declare our structure.

Structuring Structures

Our first way of declaring a structure uses the keyword "struct" followed by an open brace "{" followed by the declaration of the item variables followed by the close brace "}" followed by the structure name followed by a semicolon.

For our example this would look something like this:

```
struct
{
    char name[NAME_SIZE];
    char address[ADDRESS_SIZE];
    char major[MAJOR_SIZE];
    float gpa;
    char advisor[ADVISOR_SIZE];
} student;
```

Each of the character arrays must have predeclared constant values for their sizes, hence the use of capital letter names. You could have broken "name" or "address" into several variables or even other structures as we'll see later.

The "structure name" need not be a single variable name. You can give several different names to the same structure type by listing the names separated by commas.

For example:

```
struct
{
    int wing_span;
    int num_tires;
    double tonage;
    double fuel_cap;
} F_16, C_141, C_5A, KC_135;
```

This example shows how you can define a standard information structure that can be used for several different types of aircraft.
That's right. Wrong. It is easy and quick, as you will shortly see.

Our second way of declaring a structure uses a sort of "template" for the composition of the structure variables.

This way of declaring a structure uses the keyword "struct" followed by a structure tag followed by an open brace "{" followed by the declaration of the item variables followed by the close brace "}" followed by a semicolon. For our "student" example this would look something like:

```c
struct stu_rec {
    char name[NAME_SIZE];
    char address[ADDRESS_SIZE];
    char major[MAJOR_SIZE];
    float gpa;
    char advisor[ADVISOR_SIZE];
};
```

As you can see, the structure name has been dropped and I have added the structure tag name of "stu_rec". Defining structures in this way will allow you to define a variable of this type within your program whenever you need it.

The major difference between the two methods of declaring structures is that the first method will allocate memory space for the structure variable when the program is run through the C compiler, and the second method doesn't.

The second method only defines a structure type which you can use in later variable declarations. For example, if you have several students that you wish to identify within your program, you can use the following declaration to allocate memory space for them:

```c
struct stu_rec student_1, student_2, student_3;
```

This declares the variables "student_1", "student_2", and "student_3" to be structures of type "stu_rec".

Now that we have seen how to declare structures, it is now time to see how to access the individual members of the structure.

Access to these individual structure members is gained through the use of the structure member operator . (period).
| END | make | URL |
For example: student.gpa would be how you reference the "gpa" float variable within the "student" structure that I declared using the first method of structure declaration. Whereas, student_1.gpa is how to reference the "gpa" float variable within the "student_1" structure (of type "stu_rec") that was declared using the second method.

Let's look at another example to be sure you understand this concept.

```c
struct employees { int num_male; int num_female; int num_over_40; int num_under_40; } dep_1;
```

This declaration sets up a "template" for a structure of type "employees" as well as declares "dep_1" to be a variable of that type. This is a legal declaration that combines both methods of structure declaration.

The way in which you would reference the individual members of the declared structure "dep_1" is as follows:

```c
dep_1.num_male
```

Each of these individual variable members of the structure can be used as you would any variable of their individual type ("int").

```c
dep_1.num_under_40
```

Let's now take a quick look at how you can initialize a structure.

```c
struct planes { int tot_num; int tot_maint; int tot_avail; } planes = (50,5.45);
```

```c
struct planes F_16 = (50,5.45);
```

A structure may be initialized by listing the member values after the structure name declaration. The following two examples show how this is done.

```c
struct houses { int num_white; int num_green; int num_brick; } quarters = (165,139,127);
```

Which of the following is a way to increase the "num_brick" variable to 137?

A) houses.num_brick += 10;
B) quarters.houses.num_brick += 10;
C) quarters.num_brick += 10;
13D houses, quarters, num_brick += 10;
14 Very good.
14 B:155
15ABD No. Answer "C" is the correct one.
15 B:155
15E "E" was not a given choice. Please try again.
15 B:150
11Frame 155 T
12 *** Topic Review ***
12
12 In this topic we have looked at the concept of a structure and we
12 examined two methods of declaring them.
12
12 We have seen how to access the individual members of a declared struc-
12 ture, and we also saw how you can initialize a structure when it is
12 declared. We have seen examples of what these structures look like
12 and how they can be used.
12
12 In the next topic area I will describe "structures within structures"
12 and "arrays of structures".
12
12 See you there!
12
12 *** This concludes this topic area. ***
13END
12Frame 300 T Structures and Arrays
22 *** Introduction ***
22
22 In this topic area I will describe how structures are used within
22 structures and how to declare and use an array of structures.
22
22 The uses for these two capabilities is unlimited to say the least.
22
22 The description of how to use these two capabilities is very straight-
22 forward, so this won't take long.
22
22 Note: Variable names in all CAPS are assumed to be declared constants.
22
22 Let's get go it.
23B:305
21Frame 305 T
22 *** Structures Within Structures ***
22
22 As you may have deduced by now, there is no restriction on the types of
22 variables used within a structure. Therefore, we can have a structure
22 that contains a variable that is itself a structure.
22
22 For example:
22 Declare "employee"    * Declare "home"    * Declare "wage_earner"
struct employee {
    char f_name[FSIZE];  // employee's first name
    char m_init;  // employee's middle initial
    char l_name[LSIZE];  // employee's last name
    char street[SSIZE];  // employee's street address
    char city[CSIZE];  // employee's city
    long zip;  // employee's zip code
    float wage;  // employee's wage
};

*emp*  // *emp* is the name of an employee

struct home {
    char f_name[FSIZE];  // home's street address
    char m_init;  // home's city
    char l_name[LSIZE];  // home's zip code
    float wage;  // home's wage
};

*home*  // *home* is the name of a home

struct wage_earner {
    employee emp;  // *emp* is a member of *wage_earner*
    home home;  // *home* is a member of *wage_earner*
    char init;  // *wage_earner* doesn't have a member named *init*
};

Given:

Structure "employee"   * Structure "home"   * Structure "wage_earner"

We can now use the structure member operator . to gain access to a
specific member of our declared structure "wage_earner".

Example:

Given:

Structure "employee"   * Structure "home"   * Structure "wage_earner"

we can access the character variable used for a
wage_earner's middle initial.

Given the above, which of the following is "not" a valid variable access
expression?

A wage_earner.wage
B wage_earner.address.zip
C+ wage_earner.home.street
D wage_earner.name.m_init

Wrong. Answer "C" is the correct response.

"E" was not a given choice, please try again.

Now that we have seen how to have structures within structures, let's
take a look at how to declare an array of structures.
First we need to declare a structure:

```c
struct address {
    char street[S_SIZE];
    char city[C_SIZE];
    long zip;
};
```

We can now declare an array of this type of structure:

```c
struct address student[100];
```

Arrays of Structures Continued *

The statement: "struct address student[100];" will allocate memory space for 100 structures of type "address". Each of these structures can now be accessed by using an array index and the structure member operator (.),

For example:

```c
student[49].zip will access the variable "zip" of the 50th structure (of type "address") in the array "student".
```

```c
student[9].city = "New York"; will assign the character string "New York" to the character array "city" of the 10th structure (of type "address") in the array "student".
```

Given the declaration:

```c
struct name {
    char f_name[F_SIZE];
    char m_init;
    char l_name[L_SIZE];
} roster[50];
```

A "template" structure of type "name" is declared and an array of 50 of these structures called "roster" is declared as well. (True or False)

Very good.

Wrong. This is one way we have seen to combine the two methods of structure declaration.

*** Topic Review ***

In this topic we have looked at how structures are declared and used within other structures and we saw how to declare and use an array of structures.
Although we didn't look at very many or very involved examples of the uses of these two capabilities, I think that it is enough to introduce you to their use and will spark your ingenuity for programming applications. The rest of this lesson will discuss some other ways of working with structures in C programming.

In the next topic area (3) I will describe and show examples of how to use pointers to structures. In topic area four I will discuss how to pass structure data between functions.

*** This concludes this topic area. ***

---Frame 500 T Structures and Pointers

*** Introduction ***

In lesson four we saw that a "pointer" is actually a variable that contains the address of where some other variable resides in memory.

In this topic area I will describe how pointers are used to access structures and their members. We will take a look at a couple examples to help see this fairly straightforward technique.

Let's get started!

---Frame 505 T

*** Pointers to Structures ***

We have seen that given a structure declaration such as:

```c
struct income {
    float gross;
    float fitw;
    float s_tax;
    float fica;
} pay;
```

This declares a "template" structure of type "income" and also declares a variable "pay" to be of that type.

As we have seen, we can now access the individual members of the variable "pay" by using the "structure member operator" (.). For example: `pay.gross` will access the variable "gross" within the structure "pay".

---Frame 510 T

* Pointers to Structures Continued *

Let's now look at how we can use pointers to access the structure and its members.

Given the structure declaration: `struct income`
float gross;
float fitw;
float s_tax;
float fica;
}

pay;

We can use the pointer declaration: struct income *p_pay; to declare a pointer "p_pay" that points to a structure of type "income".

Using the statement: p_pay = &pay; we assign the starting address of variable "pay" (of structure type "income") to variable "p_pay".

```c
struct address {
    char street[S_SIZE];
    char city[C_SIZE];
    long zip;
}

home;
```

Which of the following will assign the starting address of the structure "home" to the pointer "p_home"?

A: p_home = home;
B: p_home = address;
C: p_home = &home;
D: p_home = &address;

Wrong. Response "C" is the correct one.

"E" was not a given choice. Please try again.

Now that we have defined a pointer to the structure "pay", we need to learn how to use this pointer to access the members of the structure.

The way in which this is done in C is through the use of the a special operator which is composed of a minus and greater than sign "->".

For example, if we wish to access the variable "gross" of the structure "pay" in our example, we could use the expression: p_pay->gross

This, of course, would be used in a statement such as:

```
p_pay->gross = gross_pay;
```

which would store the value of "gross_pay" in the memory location represented by "gross" within structure "pay".

```c
struct income {
    float gross;
    float fitw;
    float s_tax;
    float fica;
};

pay;
```
The special operator \texttt{->} is provided as a shorthand way of accomplishing the same thing that the unary operator \texttt{*} does.

The statement we just saw, \texttt{p_pay->gross = gross_pay;}, could have been just as easily written as: \texttt{(*p_pay).gross = gross_pay;} and would have the same result.

The problem with using the unary operator \texttt{*} (asterisk) is that it has a lower precedence than the structure member operator \texttt{.} (period). Hence, you must use parentheses to ensure proper execution.

With this in mind it is easy to see that using the provided special operator \texttt{->} is easier and clearer.

Given the structure declaration:

\begin{verbatim}
struct address {
    char street[S_SIZE];
    char city[C_SIZE];
    long zip;
} home;
\end{verbatim}

The variable "zip" can be accessed by using the expression: \texttt{p_home->&zip}

Provided "p_home" has been declared a pointer to type "address".

\begin{enumerate}
  \item True or False
  \item Very good. The correct expression is: \texttt{p_home->}zip.
  \item No. The correct expression is: \texttt{p_home->}zip.
\end{enumerate}

As a quick review,

If you have a structure declaration like:

\begin{verbatim}
struct income {
    float gross;
    float fitw;
    float s_tax;
    float fica;
} pay;
\end{verbatim}

You can access the individual structure members with expressions:

\begin{verbatim}
struct income \*p_pay;
p_pay = &pay;
p_pay->gross
p_pay->fitw
p_pay->s_tax
p_pay->fica
\end{verbatim}

In this topic area we have looked at how pointers to structures are declared and how to access the individual members of a structure using a declared pointer.
We have seen a couple examples to help illustrate this technique.

In the next topic area I will describe how to pass structure data between functions.

Hope to see you there!

### This concludes this topic area. ###

In this topic area I will describe how structure data is passed between functions.

We have seen already how to pass variables as well as pointers between functions. Passing structure data is done in much the same way. We will look at a few examples to help illustrate this concept.

Let's get started!

Using the structure we defined in the last topic area:

```c
struct income {
    float gross;
    float fitw;
    float s_tax;
    float fica;
} pay;
```

One way to pass the data contained in the structure to a called function is to pass the structure members individually. For example:

```c
compute(pay.gross, pay.fitw, pay.s_tax, pay.fica);
```

Calls function "compute" and passes the four members of structure "pay".

The called function would look something like the following in order to receive and use the passed variables:

```c
float compute(gross, fitw, s_tax, fica)
    float gross, fitw, s_tax, fica;
```
42    take_home_pay = gross - (fitw + s_tax + fica);
42    return(take_home_pay);
42 }

# Passing Structure Data Continued

42 A second way to pass the structure data to the called function is to
42 pass the entire structure. For example:
42 compute(pay); will pass the address of the beginning of structure
42 "pay" to function "compute".
42 The called function would look something like the following in order
42 to receive and use the passed structure address.
42
42 float compute(p_data)
42     struct income p_data;
42     {
42         t_h_p = p_data.gross - (p_data.fitw + p_data.s_tax + p_data.fica);
42         return(t_h_p);
42     }

# Passing Structure Data Continued

42 A third way to pass the structure data to the called function is to
42 pass a pointer to the structure. For example, if you have a structure
42 defined as:
42     struct income {
42         float gross;
42         float fitw;
42         float s_tax;
42         float fica;
42     } pay;
42 Define a pointer variable with the statement: struct income *p_pay;
42 Assign the address to the pointer variable: p_pay = &pay;
42 Then call the function: compute(p_pay);

# Passing Structure Data Continued

42 The called function would look something like the following in order
42 to receive and use the passed pointer variable:
42 float compute(pntr)
42     struct income *pntr;
42 {  t_h_p = pntr->gross - (pntr->fitw + pntr->s_tax + pntr->fica);  
42  return(t_h_p);  
42  }  
43B:730  
41Frame 730 QM  
42Which of the following is not one of the three ways of passing structure  
42data to a called function?  
43A Pass structure members individually.  
43B Pass the structure template name.  
43C Pass the entire structure.  
43D Pass a pointer to the structure.  
44 Your right.  
44 B:735  
45ACD Wrong. Answer "B" is not a valid way to pass structure data.  
45 B:735  
46E "E" was not a give choice. Please try again.  
46 B:730  
41Frame 735 T  
42 *** Lesson Five Summary ***  
42  
42 Well, we have come to the end of lesson five. If you have seen the  
42 four subject topics in this lesson, you should now be ready to take  
42 the final test. If you feel that you don't understand something well  
42 enough to pass the test, please retake the topic that is giving you  
42 problems.  
42  
42 Topic 1 gave an introduction to structures and their use.  
42  
42 Topic 2 gave a description of structures within structures and arrays  
42 of structures.  
42  
42 Topic 3 gave a description of how pointers to structures are used.  
42  
42 Topic 4 described how structure data is passed between functions.  
42  
42ENd  
51Frame 900 TT TEST OVER LESSON 5  
52 Welcome to the final test of lesson five. This test consists of seven  
52 questions over material presented in the previous four topic areas.  
52  
52 In order to successfully complete this lesson, you must achieve a  
52 minimum score of 71.4% (five out of seven questions correct).  
52  
52 If you miss a question, the correct answer will not be shown. It is  
52 up to you to research the correct answer.  
52  
52 Well, enough said. Let's get on with it. Good luck!
Which of the following can be used to declare a structure?

1. `struct structure_tag ( variable declarations );`
2. `struct ( variable declarations ); structure name;`
3. `struct ( variable declarations ) structure name;`
4. None of the above.
5. Both "A" and "C" above.

Right. (1,110 & 125)

Which of the following is a way to access the variable "num_brick"?

A. `houses.num_brick`
B. `houses.resident.num_brick`
C. `resident.num_brick`
D. `resident.houses.num_brick`

Right. (1,175-140)

"E" was not one of your choices.

In the C programming language there is no provision for the use of structures within structures because it would require too much memory overhead. (True or False)

Right. (2,305)

Which of the following is a way to declare an array of 50 such structures?

A. `array_of_address struct address[50];`
B. `struct address array_of_address[50];`
C. `struct array_of_address address[50];`
D. `address[50] struct array_of_address;`

Wrong. (2,320-325)
J5ACD Wrong. \textcolor{red}{(2,320-325)}
55 B:925
S1Frame 925 QM
525. Given the structure declaration: \texttt{struct address { char street[S_SIZE]; char city[C_SIZE]; long zip; } home;}
52
52And the pointer declaration: \texttt{struct address *p_home;}
52
52The statement: \texttt{p_home = \&home;} will assign the starting address of the
52structure "home" (of type "address") to the pointer "p_home".
52(True or False)
52Y
54 Right. \textcolor{red}{(3,510)}
54 B:930
55 Wrong. \textcolor{red}{(3,510)}
55 B:930
S1Frame 925 QM
525. Given the declaration: \texttt{struct name { char f_name[F_SIZE]; char m_init; char l_name[L_SIZE]; } roster[50];}
52
52Which of the following expressions can be used to access the variable
52"m_init" (Assume pointer "p_roster" has been properly declared.)?
52A+ \texttt{p_roster->m_init}
52B p_roster->m_init
52C p_roster->roster.m_init
52D p_roster->name->roster.m_init
54 Right. \textcolor{red}{(3,515)}
54 B:935
S1BCD Wrong. \textcolor{red}{(3,515)}
55 B:935
55E "E" was not one of your choices.
55 B:930
S1Frame 925 QM
527. Which of the following is not one of the three ways of passing structure
52data to a called function?
52A Pass structure members individually.
52B Pass the entire structure.
52C Pass the structure template name.
52D Pass a pointer to the structure.
54 Right. \textcolor{red}{(4,706,715,720)}
54 B:940
S1BCD Wrong. \textcolor{red}{(4,706,715,720)}
55 B:940
55E "E" was not one of your choices.
55 B:945
This marks the end of lesson number five. I hope that it was of some benefit to you. I am looking forward to seeing you in lesson number six. I hope that you didn’t have too much trouble with the material presented in this lesson. If you did, please voice your comments to your training monitor who will in turn contact the CAI Plans Branch at Keesler AFB, MS.

Well, let’s take a look at how you did with the test ...
THE LESSON YOU ARE ABOUT TO TAKE CONTAINS INTRODUCTORY INFORMATION ON INPUT AND OUTPUT CAPABILITIES OF THE C PROGRAMMING LANGUAGE.

THE LESSON CURRENTLY CONSISTS OF FIVE TOPICS.

The Lesson Breakdown Is As Follows:

Topic 1: Getchar and Putchar - This topic gives a description of the use of the standard I/O functions "getchar" and "putchar". (Approx. time = 5 min.)

Topic 2: Getline - This topic gives a description of the use of the standard input function "getline" and presents an example "getline" function. (Approx. time = 5 min.)

Topic 3: Scanf - This topic gives a description and examples of the standard input function "scanf". (Approx. time = 15 min.)

Lesson Breakdown Continued:

Topic 4: Printf - This topic gives a description and examples of the standard output function "printf". (Approx. time = 10 min.)
# Topic 5: Lesson 6 Test - This is the lesson test over items that have been presented in the previous four lesson topics. (Approx. time = 5 min.)

TOTAL LESSON TIME IS APPROXIMATELY 40 MINUTES.

I hope that you enjoy it!

**************************************************************************************

SELECT THE TOPIC YOU WISH TO TAKE FROM THE FOLLOWING:

**************************************************************************************

<table>
<thead>
<tr>
<th>STATUS</th>
<th>TOPIC #</th>
<th>TOPIC TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Getchar and Putchar</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Getline</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Scanf</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Printf</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Test Over Lesson 6</td>
</tr>
</tbody>
</table>

**************************************************************************************

NOTE: A "STATUS" OF "*" INDICATES TOPIC SUCCESSFULLY COMPLETED.

**************************************************************************************

1) Introduction

Input/Output (I/O) is "not" a part of the C programming language. Statements such as Print, Write, or Read are "not" available for use.

The way in which you compensate for C's lack of I/O capability is to make use of library functions supplied by the C compiler's manufacturer.

The types of functions that are provided with a specific C compiler vary from manufacturer to manufacturer, so it is suggested that you review your C compiler's documentation in order to determine what functions you can make use of.

In this topic area we will take a look at some basic I/O functions that most manufacturers provide.
In order for you to have access to the standard I/O functions provided with your C compiler you may need to include a header file that contains the definitions and declarations needed by the I/O functions.

The file name that you include depends on the compiler you are using. Typically the include statement will look something like the following:

```
#include <stdio.h> OR #include <bdscio.h>
```

Please check your compiler's documentation for the proper header file to be included, if any.

In this lesson topic we will be discussing how to use the standard I/O functions "getchar" and "putchar". We will see examples of how these two functions are called and what they do. Let's get started.

### Getchar

The function "getchar" is used to read one character at a time from the standard input device. The standard input device is by default the user's terminal keyboard.

Note: The standard input device can be changed on most systems, but how this is done will not be discussed in this course.

The format of the call to the function "getchar" is as follows:

```
c = getchar();
```

Where "c" is any variable of type "int".

What was that? Variable "c" is of type "int"! Well, that just doesn't sound right. Let's look at this a little closer.

The requirement that the variable that receives the character returned by the function "getchar" be of type "int" stems from the fact that "getchar" is a function that returns an integer value.

The only time you would run into problems in making the variable "c" a "char" type is if you were trying to detect an end of file condition. The reason for this is that EOF is typically equal to -1, which is of course an integer.

Thus, when the EOF is encountered it must be read into a variable of type "int".

For example, the following program will "not" work.
```c
main() {
    int c;
    while ((c = getchar()) != EOF)
        < some statement to deal with variable "c" >;
}

The proper way to write the program is:

main() {
    char c;
    while ((c = getchar()) != EOF)
        < some statement to deal with variable "c" >;
}

As another example, the following program will work since no check is made against "EOF".

main() {
    char c;
    while ((c = getchar()) != '\n')
        < some statement to deal with variable "c" >;
}

Here the terminating condition is when "c" is equal to the "newline" C escape sequence. As you can see, the requirement for the receiving variable of the function "getchar" to be of type "int" is not without exception. Just be aware of the fact that "getchar" returns an "int" type and this may cause you a problem if the receiving variable is not of the same type.

The "getchar" function is used to read one character at a time from standard input to the executing C program. (True or False)

Right.

Wrong. Wake up!

The function "putchar" is used to write one character at a time to the standard output device. The standard output device is by default the users terminal screen.

Note: The standard output device can be changed on most systems, but how this is done will not be discussed in this course.
```
The formats of the call to the function "putchar" is as follows:

- `putchar(c);` Where `c` is any character variable.
- `putchar('c');` Where 'c' is any character constant.
- `putchar(\c);` Where \c is any C escape sequence.

For example:

```c
main()
{
    putchar('I');
    putchar('l');
    putchar('e');
    putchar('e');
    putchar('');
}
```

This program will write the sentence: I like C. to the standard output device (terminal screen).

As another example:

```c
main()
{
    char string[] = "I like C."
    for (i = 0; string[i] != \0; i++)
        putchar(string[i]);
}
```

This program will also write the sentence: I like C. to the standard output device (terminal screen). The loop terminating expression will become "true" when the end-of-string marker (\0) is encountered.

Which of the following is "not" a correct way to use the "putchar" function?

A) `putchar(c);` Where `c` is any character variable.
B) `putchar(*c);` Where *c is a pointer to any character array.
C) `putchar('c');` Where 'c' is any character constant.
D) `putchar(\c);` Where \c is any C escape sequence.

Very good.

A: 150

ACD No. Answer "b" is the correct one.
This example shows how you can combine both the "getchar" and "putchar" functions to read & write a line of text from/to the standard I/O device.

```c
main() {
    char c;
    while ((c = getchar()) != '\n')
        putchar(c);
}
```

This program will terminate when the user hits the "Return" key at the end of his/her typed line.

In this topic we have looked at the standard I/O functions "getchar" and "putchar".

We have seen a few examples of how to access and use these functions and discussed a couple of things to be aware of in their use.

In the next topic area I will describe the I/O function "getline" and give a few examples of its use.

See you there!

*** This concludes this topic area. ***

---

In this topic area I will describe the I/O function "getline".

This function is used to read in one line of input from the standard input device (users terminal keyboard). In addition to reading a line of input, the "getline" function also keeps track of how many characters were read in.

We saw in the last topic area how to accomplish the reading of a line of input using the "getchar" function, but as you can well imagine, if you need to do this task in several points in your program it would pay to have a separate function defined which you could call.
Most C compilers have this function as part of its I/O library, but just in case your compiler manufacturer didn’t include it, I will present a version of "getline" that you can use in your programs.

```c
n = getline(input_line, 80);
```

Where "n" is any variable of type "int", "input_line" is a character array, and "80" is the maximum length of the array. When the above statement is executed the "getline" function will read a line of input from the users terminal keyboard. The above call will read in at most 78 characters. If the user were to type 78 characters and then hit the "Return" key, the actual contents of the "input_line" array would be as follows:

```
input_line[0] thru input_line[77] = characters (78 characters)
input_line[78] = \n (end of line character)
input_line[79] = \0 (end of string marker)
```

As I stated before, the "getline" function will keep track of the number of characters it reads in. What I didn’t mention is that it will return this number to the calling function if so desired.

In our example statement: `n = getline(input_line, 80);`

The variable "n" (of type "int") is where the number of characters read in is stored. This number will include the 78 characters of user input and the end of line character, but not the end of string marker. For our example this would give us a total count of 79.

How you use this number, if at all, depends on your programs application.

Which of the following is "not" true.

A  "n" must be a variable of type "int".
B  "getline" will return two values "n" and "input_line".
C  "input_line" must be a character array.
D  "80" is the maximum input line size.

Right. "getline" will return an integer value to "n", but the array "input_line" is passed as a pointer to array position input_line[0].

Answer "B" is the correct response. "getline" will return an
integer value to "n", but the array "input_line" is passed as a pointer to array position input_line[0].

"E" was not a given choice, please try again.

Let's take a look at a sample program that uses the function "getline".

```c
main()
{
    char input_line[80];
    getline(input_line,80);
    i = 0;
    while (input_line[i] != '\0') {
        putchar(input_line[i]);
        i++;
    }
}
```

This program will read in one line of input from the users terminal keyboard and print the stored line (one character at a time) on the users terminal screen.

Now that we have seen how to use the "getline" function that is usually provided with your C compiler by the manufacturer, let's take a look at how you can define your own version of the "getline" function.

The following will perform the same as the "getline" function we have just looked at and can be included in your programs if the "getline" function is not available.

```c
getline(in_line,max)
{
    char in_line[];
    int max;
    int i,c;
    for (i = 0; i < (max-1) && (c = getchar()) != EOF && c != '\n'; i++)
        in_line[i] = c;
    if (c == '\n')
        in_line[i++] = c;
    in_line[i] = '\0';
    return(i);
}
```
Given the function call statement: getline(input_line,35);

The maximum number of characters that will be read by the function "getline" is 35. (True or False)

Very good. 34 characters can be read. One character is used to store the end of string marker.

Wrong. 34 characters can be read. One character is used to store the end of string marker.

In this topic we have looked at the I/O function "getline" which may or may not be included with your C compiler's standard I/O library. We have seen a few examples of how to access and use this function and we saw a version of the function that you can include in your program if it is not available with your compiler.

In the next topic area I will describe the I/O function "scanf" and give a few examples of its use.

See you there!

This concludes this topic area.

In this topic area I will describe the I/O function "scanf".

This function is used to read characters from the standard input device (users terminal keyboard) and do some sort of conversion on the read characters. In essence the function is used to do formatted input.

We saw in the last topic area how to accomplish the reading of a line of input using the "getline" function, but if the input you wish to read is not composed of just characters you would be hard put to store the input in their intended form.

All C compilers should have the function "scanf" as part of its I/O library. Please check your compiler's documentation to be sure of this functions availability.
The format of the "scanf" function call is composed of two parts:
a format control string and the pointer arguments.

A skeleton of the function call looks like this:

```c
scanf("format control string", &arg_1, &arg_2, ..., &arg_n);
```

The format control string will be described in detail shortly. The arguments following the string must be pointers to the memory locations where the read in arguments are to be stored.

It is a fairly common mistake to try and read values into a variable by just specifying the variable name. This can not be done since "scanf" is a function and as such can only return one value. Thus, you must somehow pass it the address of where the variable is stored.

Let's now look at each part of the "format control string" of the scanf function call.

The "format control string" is made up of individual conversion specifications. Each of these conversion specifications "must" begin with a "percent sign" (%).
The next (optional) character is an "argument suppression character". This character is an asterisk (*) and indicates that the next input field is to be skipped. Thus, no assignment is made into the corresponding input argument.

The next (optional) part of the "string" is an "integer field width specifier" which is used to specify the maximum field width of the input.

The next (optional) part of the "string" is the "length modification character". This character can be one of two letters: l or h. These two letters can only be used in conjunction with certain "conversion characters" as will be described forthwith.

The last part of the "string" is the "conversion character or character class". The "conversion character" can be one of 13 different characters.

I will now give a brief description of each of these characters.

\[d\] = decimal integer (argument should point to "int" variable type.)
\[o\] = octal integer (argument should point to "int" variable type.)
\[x\] = hexadecimal integer (argument should point to "int" variable type.)
\[D\] = decimal integer (argument should point to "long" variable type.)
\[O\] = octal integer (argument should point to "long" variable type.)
\[X\] = hexadecimal integer (argument should point to "long" variable type.)
\[e\] or \[f\] = floating point number (argument should point to "float" variable type.)
\[E\] or \[F\] = floating point number (argument should point to "double" variable type.)
\[c\] = character (argument should point to "character" variable type.)
\[s\] = string (argument should point to "character array" variable type.)
\[\%\] = percent sign is expected as the next input character.

As a refresher: Integer input: \(d, o, x, D, O,\) or \(X\)
Floating point input: e, f, E, or F
Character input: c
String input: s
Percent sign input: %

Let's look at a couple of examples involving the "scanf" function call.

```c
scanf("%d%+f", &int_var, &float_var);
```

The above call will read from standard input (users terminal keyboard) two numbers of the types "integer" and "floating point real".

The users typed input numbers would be of the form: 23 45.78

The "scanf" function will read into the first argument ("int var") until a "white space" character or a character that is incompatible with the specified "format control string" is encountered.

Note: A "white space" character is defined as a "blank", "tab" (\t), or "newline" (\n).

As another example:
```c
scanf("%s%c%d%%", s_array, &int_var);
```

This "scanf" call will read a "string", "integer", and "percent sign".

The users input would look something like this: Tax = 5%

The function "scanf" will read the word "Tax" into the array "s_array", then skip the character "=", then read the integer "5", and finally read the "percent sign". No space is needed after the "5" in the users input since the "percent sign" is not compatible with the "%d" format control string. The "percent sign" is not stored anywhere.

Which of the following variables will contain a number with a decimal point?

A. w
B. x
C. y
D. z
Right.
B: 555
Wrong. Response "B" is the correct answer.

"E" was not one of your choices, please try again.

One more point on the "format control string" that I promised to talk about, namely the "length modification character".

As I mentioned, this optional character can be either the letter l or the letter h. The "length modification character" can only be used with certain "conversion characters".

You may use the letter l with the conversion characters d, o, or x to indicate that the value being read in is to be stored in a "long" rather than "int" variable type. i.e., scanf("%ld",&long);

You may use the letter h with the conversion characters d, o, or x to indicate that the value being read in is to be stored in a "short" rather than "int" variable type. i.e., scanf("%hd",&short)

As I mentioned during the description of the format of the "scanf" function call, the "format control string" begins with a percent sign and ends with either a "conversion character" or "character class".

We have seen what the "conversion character" is, but we still need to cover the "character class".

A "character class" is identified by a set of brackets [ ] following the percent sign. The "character class" is used in conjunction with a character array argument.

Let's look at two examples to demonstrate the use of "character class".

Example #1: scanf("%[abcdefghijklm]",valid_letters);

In this example an input string is read until a letter is encountered that "is not" in the "character class" specified. The character array "valid_letters" must be big enough to hold the read in input string.

Example #2: scanf("%[^abcdefghijklm]",valid_letters);

An alternate form of the "character class" uses a circumflex (^). When this form is used, the valid input becomes any character not specified in the "character class". Therefore, for example #2 above,
the input string will be read until a letter is encountered that "is"
in the "character class" specified.

In this topic we have looked at the I/O function "scanf" which is
usually included with your C compiler's standard I/O library.

We have seen a few examples of how to access and use this function
and discussed many of the special features of the function.

In the next topic area I will describe the I/O function "printf" and
give a few examples of its use.

See you there!

*** This concludes this topic area. ***

This topic area I will describe the I/O function "printf".
This function is used to convert and print specified arguments to
the standard output device (user's terminal screen). In essence the
function is used to do formatted output.

We saw in the last topic area how to accomplish formatted input by
using the "scanf" function. We will now cover how to accomplish the
task of producing output from your C program in any form you like.

All C compilers should have the function "printf" as part of its I/O
library. Please check your compiler's documentation to be sure of
this function's availability.

The format of the "printf" function call is composed of two parts:
a format control string and the arguments.

A skeleton of the function call looks like this:

```
printf("format control string", arg_1, arg_2, ..., arg_n);
```

The format control string will be described in detail shortly.
The arguments following the string have two important restrictions:

1. Their "type" must agree with the corresponding conversion
control character within the "format control string".

2. The number of arguments must agree with the number of conversion control specifications in the "format control string".

The format control string will usually contain the conversion specifications to be applied to the output sequences being printed to the output device.

However, you may also use the "printf" function to print character sequences "character for character".

For example: printf("C is GREAT"); will print: C is GREAT

The format control string usually begins with a percent sign (%) and ends with a conversion character, but can begin with C character escape sequences.

For example: printf("\n\t%d",arg1); will execute a "new line" and a "tab", then print an integer.

The "printf" function call: printf("\nI Love C"); will execute a "new line" and then print the character sequence: I Love C  (True or false)

Right. Good work!

Sorry, that is a true statement.

Let's now look at each part of the "format control string" of the "printf" function call.

The "format control string" is made up of individual conversion specifications. Each of these conversion specifications "must"
begin with a "percent sign" (%).
The next (optional) character is a "minus sign". The minus sign, if
present, indicates that the corresponding argument is to be printed
left justified in its field. If no minus sign is present then the
argument is printed right justified.
The next (optional) part of the "string" is an "integer field width
specifier" which is used to specify the minimum field width in which
the converted argument is to be printed.

The next (optional) part of the "string" is a "period". The period
is used to separate the "integer field width specifier" from the next
field of the "format control string".
The next (optional) part of the "string" is an "integer precision
specifier". This is used to specify the maximum number of digits to
be printed to the right of the decimal point (in the case of "double
and float" argument types) or the maximum number of characters (in
the case of a "character string" argument).
The next (optional) part of the "string" is the "length modification
character". This character is the letter "l". This letter can only
be used in conjunction with the "conversion characters": d, u, o, x

The last part of the "string" is the "conversion character". The
"conversion character" can be one of 9 different characters.
d = signed decimal notation
u = unsigned decimal notation
o = unsigned octal notation
x = unsigned hexadecimal notation
f = float or double decimal notation (precision default = 6)
e = float or double scientific notation (precision default = 6)
c = float or double using the shorter of e or f above
s = string
c = character

Let's look at a couple of examples involving the "printf" function call.
printf("%d %f", int_var, float_var);
The above call will print to standard output (users terminal screen) two numbers of the types "integer" and "floating point real".

The users printed output numbers would be of the form: 23 45.78

The "printf" function will print the first argument ("int_var") and then print the second argument ("float_var").

Note: A "white space" or blank character is printed between the arguments since one space appears between the conversion specifications in the "format control string".

As another example: printf("\n%6.2f",float_var);

This "printf" call will execute a "new line" and then print a "floating point real" right justified in a field of 6 print positions with 2 digits after the decimal point.

The users output would look something like this: 2561.89

The function "printf" will print the value in "float_var" using the specified format unless more print positions are needed, in which case, more print positions will be used.

Given the function call: printf("%4d %-4.2f %s %c",w,x,y,z);

Which of the following variables corresponds to the printed output: HI

A) w
B) x
C) + y
D) z

Right. HI is a string.

Wrong. HI is a string, therefore response "C" is the correct answer.

Well, we have come to the end of lesson six. If you have seen the four subject topics in this lesson, you should now be ready to take the final test. If you feel that you don’t understand something well enough to pass the test, please retake the topic that is giving you problems.

Topic 1 gave a description of the I/O functions "getchar" and "putchar".

Topic 2 gave a description of the I/O function "getline".

C - 125
Welcome to the final test of lesson six. This test consists of seven questions over material presented in the previous four topic areas.

In order to successfully complete this lesson, you must achieve a minimum score of 71.4% (five out of seven questions correct).

If you miss a question, the correct answer will not be shown. It is up to you to research the correct answer.

Well, enough said. Let's get on with it. Good luck!

1. The "getchar" function is used to read one character at a time from standard input to the executing C program. (True or False)

2. Which of the following is "not" a correct use the "putchar" function?
   - A: putchar(c); Where c is any character variable.
   - B: putchar(*c); Where *c is a pointer to any character array.
   - C: putchar('c'); Where 'c' is any character constant.
   - D: putchar(\c); Where \c is any C escape sequence.

3. Given the function call statement: n = getline(inputline,80);
   Which of the following is "not" true.
   - A: "n" must be a variable of type "int".
   - B: "getline" will return two values "n" and "input_line".
   - C: "input_line" must be a character array.
   - D: "80" is the maximum input line size.

4. Given the function call statement: getline(input_line,35);
The maximum number of characters that will be read by the function "getline" is 35. (True or False)

True.

The format of the "scanf" function call is composed of two parts: "format control string" and the "pointer arguments". (True or false)

True.

Which of the following variables will contain a number with a decimal point?

C

Richt. (5,530)

Wrong. (5,530)

"E" was not one of your choices.

Wrong.

The "printf" function call: printf("\nI Love C"); will execute a "new line" and then print the character sequence: I Love C (True or false)

Wrong.

This marks the end of lesson number six and hence the end of the course. I hope that the lesson as well as the course was of some benefit to you.

I hope that you didn't have too much trouble with the material presented in this or any of the lessons in this course. If you did, please voice your comments to your training monitor who will in turn contact the CAI Plans Branch at Keesler AFB, MS.

Well, let's take a look at how you did with the test...
File "EXIT"

# THE COURSE YOU ARE NOW LEAVING WAS WRITTEN BY CAPT FRANK DEMARCO
# IN PARTIAL FULFILLMENT OF HIS MASTERS DEGREE IN INFORMATION SYSTEMS.

| GGGGGG | 000000 | 000000 | DDDDDD | BBBBBB | YY | YY | EEEEEEEE |
| GGGGGG | 00000000 | 00000000 | DDDDDD | BBBBBB | YY | YY | EEEEEEEE |
| Gg | 00 | 00 | DD | DD | BB | BB | YY | YY | EE |
| Gg | 00 | 00 | DD | DD | BBBBBB | YYYY | EEEEEEE |
| Gg | 00 | 00 | DD | DD | BB | BB | YY | YY | EE |
| GGGGGG | 00000000 | 00000000 | DDDDDD | BBBBBB | YY | YY | EEEEEEEE |
| GGGGGG | 00000000 | 00000000 | DDDDDD | BBBBBB | YY | YY | EEEEEEEE |

| FFFFFFF | 000000 | RRRRRR | NN | NN | 000000 | WW | WW | II |
| FFFFFFF | 00000000 | RRRRRRRR | NNNN | NN | 00000000 | WW | WW | WW |
| FF | 00 | 00 | RR | RR | NN | NN | NN | 00 | 00 | WW | WW | WW |
| FF | 00 | 00 | RR | RR | NN | NN | NN | 00 | 00 | WW | WW | WW |
| FF | 00000000 | RR | RR | NN | NNNN | 00000000 | WWWWWW |
| FF | 000000 | RR | RR | NN | NN | 000000 | WWWWWW | 00 |
VITA

Captain Frank W. DeMarco was born on 8 June 1954 in Wheeling, West Virginia. He graduated from St. Johns High School in Bellaire, Ohio, in 1972 and entered the Air Force at the age of eighteen. He was honorably discharged from the Air Force in 1976 and joined the Ohio Air National Guard. In 1978 he joined the Air Force Reserve Officer Training Corps at Ohio University in Athens, Ohio. He received the degree of Bachelor of Science in Education (Mathematics) in June of 1980. Upon graduation, he received his commission in the USAF. Entering active duty in July 1980 he was assigned to the 3300 Technical Training Wing (TCHTW) at Keesler AFB, Mississippi. His duties while at Keesler included working as a World Wide Military Command and Control System (WWMCCS) mobile training team member and as a course writer for the Computer Assisted Instruction (CAI) Plans Branch of the 3300 TCHTW. In May of 1984 he entered the School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

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### Title
COMPUTER ASSISTED INSTRUCTION FOR THE "C" PROGRAMMING LANGUAGE ON THE ZENITH Z-100 MICROCOMPUTER SYSTEM

### Thesis Chairman
Dr. Henry B. Potoczy

### Professor of Mathematics

### Abstract
Title: COMPUTER ASSISTED INSTRUCTION FOR THE "C" PROGRAMMING LANGUAGE ON THE ZENITH Z-100 MICROCOMPUTER SYSTEM

### SDI Form 1473, 83 APR Edition of 1 Jan 73 is Obsolete

### DD Form 1473, 83 APR Edition of 1 Jan 73 is Obsolete

### UNCLASSIFIED SECURITY CLASSIFICATION OF THIS PAGE
The field known as "computer assisted instruction" or CAI as it is commonly called, has gained considerable interest and support since the advent of the microcomputer. More and more people, including those in supervisory positions are beginning to see the advantages, both cost and time, in having training available in the workplace. This study developed a training package for use on the Zenith Z-100 microcomputer. The package consists of six lessons and three programs. The six lessons cover various topics dealing with the "C" programming language. The objective of these lessons is to present an introduction to the "C" programming language. The three programs are written in the Pascal programming language and are used for the following functions:

1. Provide a means of displaying the lesson material.
2. Provide a means of checking student progress.
3. Provide a means of displaying course statistics.