A REWARD BOOK

$10.95

introduction to

TRS-80 LEVEL II BASIC

and computer programming

michael p. zabinski

introduction to TRS-80 LEVEL II BASIC and computer programming

MICHAEL P. ZABINSKI, Ph. D.

Professor
Fairfield University

PRENTICE-HALL, INC., Englewood Cliffs, New Jersey 07632

Library of Congress Cataloging in Publication Data

Zabinski, Michael P

Introduction to TRS-80 LEVEL II BASIC and computer programming.

Includes index.

1. TRS-80 (Computer)–Programming. 2. BASIC (Computer program language) I. Title.
QA76.8.T18Z32 001.64'2 80-15015
ISBN 0-13-499962-2 (pbk.)
ISBN 0-13-499970-3 (case)

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Editorial/production supervision
and interior design by Linda Mihatov
Cover design by RL Communications
Manufacturing buyer: Joyce Levatino

PRENTICE-HALL INTERNATIONAL, INC., *London*
PRENTICE-HALL OF AUSTRALIA PTY. LIMITED, *Sydney*
PRENTICE-HALL OF CANADA, LTD., *Toronto*
PRENTICE-HALL OF INDIA PRIVATE LIMITED, *New Delhi*
PRENTICE-HALL OF JAPAN, INC., *Tokyo*
PRENTICE-HALL OF SOUTHEAST ASIA PTE. LTD., *Singapore*
WHITEHALL BOOKS LIMITED, *Wellington, New Zealand*

preface

The computer language, BASIC, short for Beginner's All-purpose Symbolic Instruction Code, was developed at Dartmouth College by John Kemeny and Thomas Kurtz in 1964. Since then it has gained acceptance in industry, research, and education. Its use is continuously growing as computer manufacturers, and especially home computer manufacturers, recognize its simplicity and popularity. The Radio Shack TRS-80 microcomputer communicates in BASIC. This book provides an introduction to TRS-80 Level II BASIC and, through it, to some of the important concepts and applications of computer programming.

The reasons for the increased use of BASIC are many. Persons interested in learning practical computer use find BASIC to be a fast way to reach their goal. Because BASIC has a conversational, interactive nature and a simple structure, it is an attractive teaching tool with which computer programming concepts can be presented to beginners.

Just as the English language has many dialects, so does BASIC have many different implementations. The TRS-80 has two versions of BASIC commonly referred to as Levels I and II. Level II is more extensive than Level I and is the subject matter of this book. Level II BASIC contains a powerful arithmetical facility along with a large library of common mathematical and nonmathematical functions. It has many error diagnostics, which produce easily understandable error messages and excellent editing features. Level II also includes comprehensive graphic capabilities and numeric accuracy of up to 16 digits. These attributes combined with good input–output procedures make Level II BASIC an ideal computer language.

This book is directed at the beginning programmer. With a small set of instructions, the beginner can very quickly begin to write elementary computer programs. We take advantage of this feature of BASIC and emphasize those parts of the language that are most frequently used. Many examples are included to illustrate the use of BASIC and to demonstrate how a computer can be programmed to perform many different tasks. In addition, an abundance of exercises is presented at the end of each chapter with solutions to selected problems given at the end of the book. The reader is encouraged to try as many exercises as possible, for computer programming is best learned by doing.

The level of presentation and selection of material make this book suitable for a wide variety of readers. No previous experience with computers and no mathematical background beyond the basic arithmetic skills are assumed. The material is presented as it would appear on the TRS-80 video display. A unique feature of this book is the inclusion of explanatory com-

ments alongside the computer displays. These comments highlight and reinforce the text discussion by pointing out new procedures and emphasizing important points. The reader would therefore benefit by working along with the text, trying out the illustrative examples on the computer, and experimenting with variations. The way to learn a new computer language is to use it. Each student should run as many programs as he has time for so as to acquire a feel for this new tool.

This is a textbook suitable for the self-learner or for a one-semester introductory course. It should not be viewed as a reference manual in BASIC. The primary purpose of the book is to introduce Level II BASIC as well as computer-programming concepts. It is for the nonspecialist who wants to learn to use the TRS-80 effectively.

I am greatly indebted to many people who have contributed to the development of this book. Particular thanks are due to Stephen Cline, editor, Prentice-Hall, and to David Gunzel, director technical publications, Radio Shack. I also express my appreciation to Ann Hannon of Greenwich High School and to the teachers of the Orange Public Schools for reviewing the manuscript and providing helpful suggestions. In addition, I wish to thank John Donovan, Richard Golden, Edward Hanlon, Howard Hecht, and John McCann for their support in the preparation of this text and my wife whose advice and typing were magnificent. Programming for the chapter exercises in this book was done–brilliantly–by Michael Galaty.

MICHAEL P. ZABINSKI, Ph. D.

list of examples

Chapter 7

Chapter 8

Chapter 9

Chapter 10

contents

introduction

The computer revolution is here! Today, computers are invading virtually every aspect of life in America. They are changing the way we work, play, and even think. That they have affected the lives of nearly all of us is indisputable. Their impact has been experienced in areas as widely separated as space research and primary instruction. We live in a world that is increasingly dependent on computers. These machines not only calculate our paychecks and our bank balances, but they are invading areas where their application once seemed inconceivable. The physician may use the computer to diagnose a case, the attorney to research a legal matter, the policeman to investigate the records of an alleged criminal, and a history teacher to simulate the Civil War. It now seems improbable that any career will remain untouched by computers, as computers are penetrating directly or indirectly into nearly every aspect of human affairs.

The seemingly unlimited usefulness of the computer itself has been augmented by its rapid development. The number of computers produced has risen dramatically. In the early 1950s there were less than 1000 computers in existence. By 1976 the number of computers had risen to 200,000. This phenomenal growth is primarily due to the major scientific advances in computer design. The first electronic computer, the ENIAC, which was huge and filled an entire room, was built in 1946. It consisted of 18,000 vacuum tubes, and tended to overheat and break down. Since that time, with the advent of transistors, integrated circuits, and the silicon chip, computers have become smaller, more reliable, faster, and less expensive. We distinguish between computers, minicomputers, and microcomputers. Around 1965 the least expensive computers were called minicomputers. In general, they are less powerful, cheaper, and smaller, although there is considerable overlap. To some extent history repeated itself with the advent of the microcomputer. In the early 1970s, very low cost computer products began to appear and were called microcomputers. The prefix micro- applies to the very small size as compared with a mini. Once again there is considerable overlap between micro- and minicomputers. Minicomputers lowered the price of computers to less than $100,000 and brought the computer into the laboratory and the manufacturing plant's production line. Microcomputers reduced the price of computers to below $1,000 and brought the computer into the small business and the home.

Regardless of size and price, all computers possess common characteristics of design and performance. Typically, a computer consists of five units: input, output, memory, arithmetic, and control. Information must be fed into the computer as **input**, for example, via the keyboard or punched cards.

The data or instructions are stored in the computer's **memory**. Computer storage can be visualized as a set of post-office boxes with each box capable of holding a single number or character of information. These boxes are arranged in such a way that their contents can be easily reached or accessed. Memory holds the information received, the commands to be followed, and the results of work accomplished. The actual calculations take place in the **arithmetic** unit. Besides calculating, a computer can make comparisons to determine whether two quantities differ. Such comparisons are also made in the arithmetic unit. The results of the computer's work are displayed through the **output** unit. In the case of the TRS-80, the display may be on the screen or on the printer. The **control** unit coordinates the flow of data. Like the conductor of an orchestra, it coordinates the activities of the units of the computer to ensure proper processing.

A basic characteristic of the computer is that it has no inherent intelligence. It does not understand any human language; nevertheless, a computer can act upon instructions given in a language that is well suited to tasks the computer can accomplish. The language of the TRS-80 is BASIC; it allows you to create instructions using familiar English terms. Another important characteristic of a computer is its ability to carry out instructions extremely quickly. This fact, along with the observation that many tasks involve repeating similar operations, has led to the concept of a **computer program**. A program consists of a set of instructions provided to the computer in advance of actual computations. By first giving a computer all the instructions needed to accomplish a task, and then telling it to start executing the instructions, the computer can work at its own tremendous speed, repeating particular operations as many times as necessary to get the job done.

The language of BASIC, the Beginner's All-purpose Symbolic Instruction Code, was born in 1964. It was developed at Dartmouth College by Kemeny and Kurtz. The BASIC language is oriented to conversational use at the computer. The idea was to make the language syntax very easy to learn and use. In 1967, Kemeny and Kurtz reported that they had introduced some 2,000 students at Dartmouth to BASIC, indeed a very basic computer language.

chapter 1 your TRS-80 computer

1.1 GETTING STARTED

The TRS-80 computer consists of four units. The **power supply**, the **keyboard**, the **video monitor**, and the **cassette recorder**. The keyboard is used to type information into the computer. The information we type in and the computer's responses are displayed on the screen. The computer itself is inside the keyboard. The cassette recorder is used to load from tape programs into the computer or to record programs on tape. These units need to be connected and plugged in carefully. Follow the detailed instructions that accompany the computer, and be sure you get all the plugs to fit properly. To turn on the computer, press the power button on the video display and the power button on the back of the keyboard. Once the power is turned on, the red light on the keyboard lights up and the display

```
MEMORY SIZE?
```

appears on the screen. Press the white key labeled ENTER. The computer responds

```
RADIO SHACK LEVEL II BASIC
READY
>_
```

The computer is now ready for your instructions in Level II BASIC. Computers equipped with Level I BASIC display the READY immediately after power has been turned on.

1.2 THE KEYBOARD

BASIC is a conversational computer language that enables us to carry on a dialog with the computer. We talk to the computer by using a typewriter-like keyboard. We type our messages and transmit them to the computer. At the same time, the information we type also appears on the screen.

The keyboard is divided into two zones. The first zone is the primary part of the keyboard; it contains all the keys necessary to operate the computer. The second zone, located on the right side of the keyboard, contains a duplicate set of numeric keys and a second white ENTER key. It is a

calculator-style numeric keypad that makes typing of numbers convenient and efficient for those who are accustomed to calculator usage. Some earlier model keyboards do not have a numeric keypad. The letters of the alphabet shown on the keys print only in capitals. The SHIFT key need not (but may) be pressed for the letters to be displayed in capitals. The letter O and the number zero should not be confused since they are not interchangeable. To avoid confusion, the number zero is slashed (Ø)

Some of the keys are shared by two characters. To type the upper character press the SHIFT key. This is just like typing capitals on a regular typewriter. For convenience the keyboard has two SHIFT keys located at the right and left ends of the bottom row of keys. Aside from the usual characters, such as letters, digits, addition, subtraction, and punctuation, several characters are peculiar to BASIC. The multiplication sign is a star (*), the division sign is a slash (/), and the exponent is an up-arrow (↑). In addition, there are other special-purpose keys, for example, #, @, $, and %. These will be introduced later. Finally, several keys located along the right and left edges of the keyboard are used to manipulate where on the screen the information is typed. These include the CLEAR, →, ←, BREAK, ↑ and ↓ keys.

1.3 COMMUNICATING WITH THE COMPUTER

When we first turned on the computer we pressed ENTER to obtain the READY followed by >_ . The _ is called the **cursor**. We now do some typing. Type I AM HAPPY. The space bar is used for spaces between words. Notice how the cursor moves to the right. The cursor indicates where the next character will appear on the screen. Suppose we typed by mistake the word HPPY (the A is missing). To erase the text, we press the ← key. Each time we press the key one character is erased. The shift ← (press the SHIFT and ← keys at the same time) erases the entire line at once. Erase it.

Each line on the screen can hold up to 64 characters. Enter any text and count them. As you type briskly, you may press a second key before you have released the first. At first type slowly to be sure no extraneous characters are typed. Now erase the line and type in the entire ABC in double letters, AABBCCDDEE . . . Press shift → and notice that the letters are suddenly twice the size and that every other letter of the AABBCC . . . text has been deleted. Each letter of the ABC now only appears once. Continue typing digits and other characters. Up to 32 characters fit on a line. When the line is filled, the cursor automatically moves to the next line. To erase the line, press shift ←. The enlarged cursor remains. Additional typing will continue to appear in the 32 character per line format. To return to the normal type size, press CLEAR. This key clears the screen and places the smaller cursor at the top left corner of the screen. We can now type 64 characters per line.

Press the ↓ key. It moves the cursor down along the left edge. When it is at its lowest position, type your name. Then press the ↓ key 15 times and watch your name move up to the top of the screen. There are 16 lines on the screen. Repeat this exercise. Press CLEAR and then press ↓ to move the cursor to the bottom left corner of the screen. Now press 1, ↓, 2, ↓, 3, ↓, ... 15, ↓, 16. Subsequently, continue to type in ↓, 17, ↓, 18, and notice how the first few numbers disappear from the display. Press CLEAR to erase the screen and to place the cursor at the top left corner.

So far we have not truly communicated with the computer. We have typed information onto the screen but did not transmit it to the computer. To transmit information to the computer, the ENTER key must be pressed. Type your name and press ENTER.

	COMMENTS
TRS-80	Type in a name and press ENTER.
?SN ERROR	Computer responds: SyNtax error.
READY	
>_	The cursor is waiting.

Oops! What happened? The computer did not understand our entry and therefore responded with the error message. This is one of many types of error messages that the computer uses to inform you of errors. To avoid such error messages, we must adhere to the rules of BASIC. We must learn how to properly communicate with the computer.

chapter 2 specifying information

The great power of computers lies in their ability to handle a large amount of information rapidly. We begin our study of BASIC by looking at some of the types of information that we can use. The two types of information discussed in this chapter are **numerical information** and **character information.** We can request that the computer display information on the screen by using the instruction **PRINT.**

2.1 NUMERICAL INFORMATION

Numbers such as 18, 157, or 89 can represent information of importance to you, such as your age, weight, and grade on your last exam. Decimal numbers are expressed in the usual manner, for example, 18.5 or 3.14159.

A number such as 18.5 is a positive number. It could therefore be written equally well as +18.5. The plus sign is optional. In the case of a negative number, we must place the minus sign before the number.

	COMMENTS

`PRINT 3.0`
` 3`
`PRINT 3.120`
` 3.12`
	You type in PRINT followed by a number. Then press ENTER. That number is then displayed by the computer on the screen. Note that trailing zeros after the decimal point are dropped, and for values less than one, the zero before the decimal point is also deleted. The + sign is not printed; the - sign is printed. A number without a sign is always positive.

`PRINT +3.12` ` 3.12`	Positive numbers are displayed with a leading blank instead of the plus sign.
`PRINT -3.12` `-3.12`	Negative numbers are displayed without a leading blank.
`PRINT -0.3120` `-.312`	Leading and trailing zeros are not displayed.
`? 3` ` 3`	The ? is an **abbreviation** for PRINT. In contrast to Level I BASIC, Level II allows only for very few abbreviations. For clarity, we do not use the abbreviated form.

REMEMBER: Always press ENTER to transmit your message to the computer.

BASIC uses a modified version of **scientific notation** for representing very large numbers or very small numbers. Scientific notation breaks a number into two parts, a number between 1 and 10 and an exponent of 10. For example, the speed of light is about 300 million meters per second, which can be written as 300,000,000 or in scientific notation as 3×10^8. In BASIC we can express this numerical information as the number 3E8, where E indicates that 8 is the exponent of 10. The following examples illustrate scientific notation.

Number	Scientific Notation	BASIC
1230000	1.23×10^6	1.23E+06[a]
0.000123	1.23×10^{-4}	1.23E-04

[a]BASIC replaces "times ten to the" by E.

```
                                    COMMENTS
PRINT 100000                        Once the ENTER key is pressed the
 100000                              computer displays 100000.

PRINT 1000000                       At 1 million, scientific notation is
 1E+06                               used.

PRINT 1E+5
 100000

PRINT 1E6                           1E6 is a valid numeric constant.
 1E+06

PRINT 0.01
  01
 PRINT 0.001                        Scientific notation is used by the
 1E-03                               computer for numeric constants
                                     of 0.001 or less.
```

2.2 CHARACTER INFORMATION

In addition to numerical information, BASIC also allows for the use of character information in the form of **character strings**. Character strings may consist of a single character such as

"A", "B", "C", "2", "3", "*", "+", "="

or several characters such as

"ABC", "23", "*+="

Character information must be enclosed in quotation marks.