

The background of the cover is a dark, textured blue. Overlaid on this are several overlapping, semi-transparent squares in various colors: red, yellow, blue, and green. Each square contains a large, black, stylized number '2'. The squares are arranged in a diagonal pattern from the top-left towards the bottom-right. The text is positioned in the upper right quadrant of the cover.

*Scheme and the Art
of Programming*

*George Springer and
Daniel P. Friedman*



Digitized by the Internet Archive
in 2012

<http://archive.org/details/schemeartofpro00incs>

**Scheme
and
The Art of Programming**

George Springer
Daniel P. Friedman

Foreword by Guy L. Steele Jr.

**Scheme
and
The Art of Programming**

The MIT Press
Cambridge, Massachusetts London, England

McGraw-Hill Book Company
New York St. Louis San Francisco Montreal Toronto

Second Printing, 1990

© 1989 The Massachusetts Institute of Technology

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher.

This book was printed and bound in the United States of America

Library of Congress Cataloging-in-Publication Data
Springer, George, 1924—

Scheme and the art of programming / George Springer, Daniel P. Friedman.

p. cm. — (The MIT electrical engineering and computer science series)

Includes bibliographical references.

ISBN 0-262-19288-8 (MIT Press) ISBN 0-07-060522-X (McGraw-Hill)

1. Electronic digital computers—Programming. 2. Object-oriented programming. I. Friedman, Daniel P. II. Title. III. Series.

QA76.6.S686 1990

005.1—dc20

89-12949
CIP

Contents

To our families and our students.

Foreword	ix
Preface	xv
Acknowledgments	xviii

Part I Data 1

Chapter 1 Data and Statistics	1
1.1 Descriptive	1
1.2 The Graphical	1
1.3 Summary Statistics	1
1.4 Computing the	1
1.5 Taking the Test	1
Chapter 2 Probability and Statistics	1
2.1 Overview	1
2.2 Probability	1
2.3 Conditional	1
2.4 Random	1
2.5 Theorems and	1

Contents

Foreword	<i>xiii</i>
Preface	<i>xix</i>
Acknowledgments	<i>xxiii</i>

Part 1 Data 1

Chapter 1 Data and Operators 3

1.1 Introduction	3
1.2 The Computer	6
1.3 Numbers and Symbols	6
1.4 Constructing Lists	14
1.5 Taking Lists Apart	19

Chapter 2 Procedures and Recursion 31

2.1 Overview	31
2.2 Procedures	31
2.3 Conditional Expressions	40
2.4 Recursion	46
2.5 Tracing and Debugging	57

Chapter 3 Data Abstraction and Numbers 73

3.1 Overview 73

3.2 Operations on Numbers 73

3.3 Exact Arithmetic and Data Abstraction 84

Chapter 4 Data Driven Recursion 95

4.1 Overview 95

4.2 Flat Recursion 95

4.3 Deep Recursion 101

4.4 Tree Representation of Lists 108

4.5 Numerical Recursion and Iteration 115

4.6 Analyzing the Fibonacci Algorithm 120

Chapter 5 Locally Defined Procedures 129

5.1 Overview 129

5.2 Let and Letrec 129

5.3 Symbolic Manipulation of Polynomials 142

5.4 Binary Numbers 155

Chapter 6 Interactive Programming 163

6.1 Overview 163

6.2 Strings 163

6.3 Implicit begin 166

6.4 Input and Output 168

6.5 Two Famous Problems 178

Part 2 Procedures as Values 193

Chapter 7 Abstracting Procedures 195

7.1 Overview 195

7.2 Procedures as Arguments and Values 195

7.3 Currying	210
7.4 Procedural Abstraction of Flat Recursion	218
7.5 Procedural Abstraction of Deep Recursion	223

Chapter 8 Sets and Relations 231

8.1 Overview	231
8.2 Quantifiers	231
8.3 Sets	236
8.4 Representing Sets	249
8.5 Ordered Pairs, Functions and Relations	255

Part 3 Managing State 265

Chapter 9 Using Vectors 267

9.1 Overview	267
9.2 Vectors	267
9.3 Representing Vectors	278
9.4 Matrices	290

Chapter 10 Sorting and Searching 303

10.1 Overview	303
10.2 Sorting	303
10.3 Searching	329
10.4 Relational Calculus	332

Chapter 11 Mutation 341

11.1 Overview	341
11.2 Assignment and State	341
11.3 Box-and-Pointer Representation of Cons Cells	360

Chapter 12 Object-Oriented Programming 383

12.1 Overview	383
12.2 Boxes, Counters, Accumulators, and Gauges	383
12.3 Stacks	396
12.4 Queues	399
12.5 Circular Lists	403
12.6 Buckets and Hash Tables	409

Chapter 13 Simulation: Objects in Action 425

13.1 Overview	425
13.2 Randomness	425
13.3 The Gas Station Simulation	430

Part 4 Extending the Language 447

Chapter 14 Declaring Special Forms 449

14.1 Overview	449
14.2 Declaring a Simple Special Form	450
14.3 Macros	454

Chapter 15 Using Streams 475

15.1 Overview	475
15.2 Delayed Lists	475
15.3 Streams	482
15.4 Using Character Data	496
15.5 Files	500

Part 5 Control 513

Chapter 16 Introduction to Continuations 515