## **Essential Computer Science**

A Programmer's Guide to Foundational Concepts

Paul D. Crutcher Neeraj Kumar Singh Peter Tiegs

**Apress**®

## **Essential Computer Science**

A Programmer's Guide to Foundational Concepts

Paul D. Crutcher Neeraj Kumar Singh Peter Tiegs

**Apress**®

## Essential Computer Science: A Programmer's Guide to Foundational Concepts

Paul D. Crutcher Welches, OR, USA Neeraj Kumar Singh Bangalore, Karnataka, India

Peter Tiegs Hillsboro, OR, USA

ISBN-13 (pbk): 978-1-4842-7106-3

ISBN-13 (electronic): 978-1-4842-7107-0

https://doi.org/10.1007/978-1-4842-7107-0

## Copyright © 2021 by Paul D. Crutcher, Neeraj Kumar Singh, and Peter Tiegs

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

Trademarked names, logos, and images may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, logo, or image we use the names, logos, and images only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Managing Director, Apress Media LLC: Welmoed Spahr

Acquisitions Editor: Susan McDermott Development Editor: Laura Berendson Coordinating Editor: Rita Fernando

Cover designed by eStudioCalamar

Cover image designed by Freepik (www.freepik.com)

Distributed to the book trade worldwide by Springer Science+Business Media New York, 1 New York Plaza, New York, NY 10004. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springeronline.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a **Delaware** corporation.

For information on translations, please e-mail booktranslations@springernature.com; for reprint, paperback, or audio rights, please e-mail bookpermissions@springernature.com.

Apress titles may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Print and eBook Bulk Sales web page at http://www.apress.com/bulk-sales.

Any source code or other supplementary material referenced by the author in this book is available to readers on GitHub via the book's product page, located at www.apress.com/9781484271063. For more detailed information, please visit http://www.apress.com/source-code.

Printed on acid-free paper

To my wife, Lisa, for her unending support and encouragement; to my sons currently studying computer science, Kyle and Cameron, may this be a bit of inspiration for their journey in life; and to the memory of my father, Edwin Lee Crutcher, who passed away while I worked on this book. I love you, Dad!

—Paul

To my wife, Shilpi, for her unwavering support.

—Neeraj

To Karen, Jane, Josephine, Henri, and Jeanette, my family, for all of their support, patience, and encouragement.

—Peter