

CRACKING *the* CODING INTERVIEW

189 PROGRAMMING QUESTIONS & SOLUTIONS



GAYLE LAAKMANN MCDOWELL

Author of Cracking the PM Interview and Cracking the Tech Career

6TH
EDITION

CRACKING THE CODING INTERVIEW, SIXTH EDITION

Copyright © 2015 by CareerCup.

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means, including information storage and retrieval systems, without permission in writing from the author or publisher, except by a reviewer who may quote brief passages in a review.

Published by CareerCup, LLC, Palo Alto, CA. Version 6.015006029017023.

For more information, contact support@careercup.com.

978-0-9847828-5-7 (ISBN 13)

Introduction

Introduction	2
I. The Interview Process	4
Why?	4
How Questions are Selected	6
It's All Relative	7
Frequently Asked Questions	7
II. Behind the Scenes.	8
The Microsoft Interview	9
The Amazon Interview	10
The Google Interview	10
The Apple Interview	11
The Facebook Interview	12
The Palantir Interview	13
III. Special Situations	15
Experienced Candidates	15
Testers and SDETs	15
Product (and Program) Management	16
Dev Lead and Managers	17
Startups	18
Acquisitions and Acquires	19
For Interviewers	21
IV. Before the Interview	26
Getting the Right Experience.	26
Writing a Great Resume	27
Preparation Map.	30
V. Behavioral Questions	32
Interview Preparation Grid	32
Know Your Technical Projects.	33
Responding to Behavioral Questions	34
So, tell me about yourself...	36
VI. Big O	38
An Analogy	38
Time Complexity.	38
Space Complexity	40
Drop the Constants	41
Drop the Non-Dominant Terms	42

Multi-Part Algorithms: Add vs. Multiply	42
Amortized Time	43
Log N Runtimes	44
Recursive Runtimes	44
Examples and Exercises	45
VII. Technical Questions	60
How to Prepare	60
What You Need To Know	60
Walking Through a Problem	62
Optimize & Solve Technique #1: Look for BUD	67
Optimize & Solve Technique #2: DIY (Do It Yourself)	69
Optimize & Solve Technique #3: Simplify and Generalize	71
Optimize & Solve Technique #4: Base Case and Build	71
Optimize & Solve Technique #5: Data Structure Brainstorm	72
Best Conceivable Runtime (BCR)	72
Handling Incorrect Answers	76
When You've Heard a Question Before	76
The "Perfect" Language for Interviews	76
What Good Coding Looks Like	77
Don't Give Up!	81
VIII. The Offer and Beyond	82
Handling Offers and Rejection	82
Evaluating the Offer	83
Negotiation	84
On the Job	85
IX. Interview Questions	87
Data Structures	88
Chapter 1 Arrays and Strings	88
Hash Tables	88
ArrayList & Resizable Arrays	89
StringBuilder	89
Chapter 2 Linked Lists	92
Creating a Linked List	92
Deleting a Node from a Singly Linked List	93
The "Runner" Technique	93
Recursive Problems	93

Multi-Part Algorithms: Add vs. Multiply	42
Amortized Time	43
Log N Runtimes	44
Recursive Runtimes	44
Examples and Exercises	45
VII. Technical Questions	60
How to Prepare	60
What You Need To Know	60
Walking Through a Problem	62
Optimize & Solve Technique #1: Look for BUD	67
Optimize & Solve Technique #2: DIY (Do It Yourself)	69
Optimize & Solve Technique #3: Simplify and Generalize	71
Optimize & Solve Technique #4: Base Case and Build	71
Optimize & Solve Technique #5: Data Structure Brainstorm	72
Best Conceivable Runtime (BCR)	72
Handling Incorrect Answers	76
When You've Heard a Question Before	76
The "Perfect" Language for Interviews	76
What Good Coding Looks Like	77
Don't Give Up!	81
VIII. The Offer and Beyond	82
Handling Offers and Rejection	82
Evaluating the Offer	83
Negotiation	84
On the Job	85
IX. Interview Questions	87
Data Structures	88
Chapter 1 Arrays and Strings	88
Hash Tables	88
ArrayList & Resizable Arrays	89
StringBuilder	89
Chapter 2 Linked Lists	92
Creating a Linked List	92
Deleting a Node from a Singly Linked List	93
The "Runner" Technique	93
Recursive Problems	93

Introduction

Chapter 3 Stacks and Queues	96
<i>Implementing a Stack</i>	96
<i>Implementing a Queue</i>	97
Chapter 4 Trees and Graphs	100
<i>Types of Trees</i>	100
<i>Binary Tree Traversal</i>	103
<i>Binary Heaps (Min-Heaps and Max-Heaps)</i>	103
<i>Tries (Prefix Trees)</i>	105
<i>Graphs</i>	105
<i>Graph Search</i>	107
Concepts and Algorithms	112
Chapter 5 Bit Manipulation	112
<i>Bit Manipulation By Hand</i>	112
<i>Bit Facts and Tricks</i>	112
<i>Two's Complement and Negative Numbers</i>	113
<i>Arithmetic vs. Logical Right Shift</i>	113
<i>Common Bit Tasks: Getting and Setting</i>	114
Chapter 6 Math and Logic Puzzles	117
<i>Prime Numbers</i>	117
<i>Probability</i>	119
<i>Start Talking</i>	121
<i>Develop Rules and Patterns</i>	121
<i>Worst Case Shifting</i>	122
<i>Algorithm Approaches</i>	122
Chapter 7 Object-Oriented Design	125
<i>How to Approach</i>	125
<i>Design Patterns</i>	126
Chapter 8 Recursion and Dynamic Programming	130
<i>How to Approach</i>	130
<i>Recursive vs. Iterative Solutions</i>	131
<i>Dynamic Programming & Memoization</i>	131
Chapter 9 System Design and Scalability	137
<i>Handling the Questions</i>	137
<i>Design: Step-By-Step</i>	138
<i>Algorithms that Scale: Step-By-Step</i>	139
<i>Key Concepts</i>	140

<i>Considerations</i>	142
<i>There is no "perfect" system.</i>	143
<i>Example Problem.</i>	143
Chapter 10 Sorting and Searching.	146
<i>Common Sorting Algorithms</i>	146
<i>Searching Algorithms</i>	149
Chapter 11 Testing.	152
<i>What the Interviewer Is Looking For</i>	152
<i>Testing a Real World Object</i>	153
<i>Testing a Piece of Software</i>	154
<i>Testing a Function</i>	155
<i>Troubleshooting Questions</i>	156
Knowledge Based	158
Chapter 12 C and C++	158
<i>Classes and Inheritance.</i>	158
<i>Constructors and Destructors.</i>	159
<i>Virtual Functions</i>	159
<i>Virtual Destructor</i>	160
<i>Default Values.</i>	161
<i>Operator Overloading.</i>	161
<i>Pointers and References</i>	162
<i>Templates.</i>	163
Chapter 13 Java.	165
<i>How to Approach.</i>	165
<i>Overloading vs. Overriding</i>	165
<i>Collection Framework.</i>	166
Chapter 14 Databases.	169
<i>SQL Syntax and Variations.</i>	169
<i>Denormalized vs. Normalized Databases.</i>	169
<i>SQL Statements</i>	169
<i>Small Database Design.</i>	171
<i>Large Database Design.</i>	172
Chapter 15 Threads and Locks	174
<i>Threads in Java</i>	174
<i>Synchronization and Locks</i>	176
<i>Deadlocks and Deadlock Prevention.</i>	179

<i>Considerations</i>	142
<i>There is no "perfect" system.</i>	143
<i>Example Problem.</i>	143
Chapter 10 <i>Sorting and Searching.</i>	146
<i>Common Sorting Algorithms</i>	146
<i>Searching Algorithms</i>	149
Chapter 11 <i>Testing.</i>	152
<i>What the Interviewer Is Looking For</i>	152
<i>Testing a Real World Object</i>	153
<i>Testing a Piece of Software</i>	154
<i>Testing a Function</i>	155
<i>Troubleshooting Questions</i>	156
Knowledge Based	158
Chapter 12 <i>C and C++</i>	158
<i>Classes and Inheritance.</i>	158
<i>Constructors and Destructors.</i>	159
<i>Virtual Functions</i>	159
<i>Virtual Destructor</i>	160
<i>Default Values.</i>	161
<i>Operator Overloading.</i>	161
<i>Pointers and References</i>	162
<i>Templates.</i>	163
Chapter 13 <i>Java.</i>	165
<i>How to Approach.</i>	165
<i>Overloading vs. Overriding</i>	165
<i>Collection Framework.</i>	166
Chapter 14 <i>Databases.</i>	169
<i>SQL Syntax and Variations.</i>	169
<i>Denormalized vs. Normalized Databases.</i>	169
<i>SQL Statements</i>	169
<i>Small Database Design.</i>	171
<i>Large Database Design.</i>	172
Chapter 15 <i>Threads and Locks</i>	174
<i>Threads in Java</i>	174
<i>Synchronization and Locks</i>	176
<i>Deadlocks and Deadlock Prevention.</i>	179

My Passion

Teaching is my passion. I love helping people understand new concepts and giving them tools to help them excel in their passions.

My first official experience teaching was in college at the University of Pennsylvania, when I became a teaching assistant for an undergraduate computer science course during my second year. I went on to TA for several other courses, and I eventually launched my own computer science course there, focused on hands-on skills.

As an engineer at Google, training and mentoring new engineers were some of the things I enjoyed most. I even used my “20% time” to teach two computer science courses at the University of Washington.

Now, years later, I continue to teach computer science concepts, but this time with the goal of preparing engineers at startups for their acquisition interviews. I’ve seen their mistakes and struggles, and I’ve developed techniques and strategies to help them combat those very issues.

Cracking the Coding Interview*, *Cracking the PM Interview*, *Cracking the Tech Career*, and *CareerCup reflect my passion for teaching. Even now, you can often find me “hanging out” at CareerCup.com, helping users who stop by for assistance.

Join us.

Gayle L. McDowell



The Interview Process

At most of the top tech companies (and many other companies), algorithm and coding problems form the largest component of the interview process. Think of these as problem-solving questions. The interviewer is looking to evaluate your ability to solve algorithmic problems you haven't seen before.

Very often, you might get through only one question in an interview. Forty-five minutes is not a long time, and it's difficult to get through several different questions in that time frame.

You should do your best to talk out loud throughout the problem and explain your thought process. Your interviewer might jump in sometimes to help you; let them. It's normal and doesn't really mean that you're doing poorly. (That said, of course not needing hints is even better.)

At the end of the interview, the interviewer will walk away with a gut feel for how you did. A numeric score might be assigned to your performance, but it's not actually a quantitative assessment. There's no chart that says how many points you get for different things. It just doesn't work like that.

Rather, your interviewer will make an assessment of your performance, usually based on the following:

- **Analytical skills:** Did you need much help solving the problem? How optimal was your solution? How long did it take you to arrive at a solution? If you had to design/architect a new solution, did you structure the problem well and think through the tradeoffs of different decisions?
- **Coding skills:** Were you able to successfully translate your algorithm to reasonable code? Was it clean and well-organized? Did you think about potential errors? Did you use good style?
- **Technical knowledge / Computer Science fundamentals:** Do you have a strong foundation in computer science and the relevant technologies?
- **Experience:** Have you made good technical decisions in the past? Have you built interesting, challenging projects? Have you shown drive, initiative, and other important factors?
- **Culture fit / Communication skills:** Do your personality and values fit with the company and team? Did you communicate well with your interviewer?

The weighting of these areas will vary based on the question, interviewer, role, team, and company. In a standard algorithm question, it might be almost entirely the first three of those.

► Why?

This is one of the most common questions candidates have as they get started with this process. Why do things this way? After all,

1. Lots of great candidates don't do well in these sorts of interviews.

2. You could look up the answer if it did ever come up.
3. You rarely have to use data structures such as binary search trees in the real world. If you did need to, you could surely learn it.
4. Whiteboard coding is an artificial environment. You would never code on the whiteboard in the real world, obviously.

These complaints aren't without merit. In fact, I agree with all of them, at least in part.

At the same time, there is reason to do things this way for some—not all—positions. It's not important that you agree with this logic, but it is a good idea to understand why these questions are being asked. It helps offer a little insight into the interviewer's mindset.

False negatives are acceptable.

This is sad (and frustrating for candidates), but true.

From the company's perspective, it's actually acceptable that some good candidates are rejected. The company is out to build a great set of employees. They can accept that they miss out on some good people. They'd prefer not to, of course, as it raises their recruiting costs. It is an acceptable tradeoff, though, provided they can still hire enough good people.

They're far more concerned with false positives: people who do well in an interview but are not in fact very good.

Problem-solving skills are valuable.

If you're able to work through several hard problems (with some help, perhaps), you're probably pretty good at developing optimal algorithms. You're smart.

Smart people tend to do good things, and that's valuable at a company. It's not the only thing that matters, of course, but it is a really good thing.

Basic data structure and algorithm knowledge is useful.

Many interviewers would argue that basic computer science knowledge is, in fact, useful. Understanding trees, graphs, lists, sorting, and other knowledge does come up periodically. When it does, it's really valuable.

Could you learn it as needed? Sure. But it's very difficult to know that you should use a binary search tree if you don't know of its existence. And if you do know of its existence, then you pretty much know the basics.

Other interviewers justify the reliance on data structures and algorithms by arguing that it's a good "proxy." Even if the skills wouldn't be that hard to learn on their own, they say it's reasonably well-correlated with being a good developer. It means that you've either gone through a computer science program (in which case you've learned and retained a reasonably broad set of technical knowledge) or learned this stuff on your own. Either way, it's a good sign.

There's another reason why data structure and algorithm knowledge comes up: because it's hard to ask problem-solving questions that *don't* involve them. It turns out that the vast majority of problem-solving questions involve some of these basics. When enough candidates know these basics, it's easy to get into a pattern of asking questions with them.

I | The Interview Process

Whiteboards let you focus on what matters.

It's absolutely true that you'd struggle with writing perfect code on a whiteboard. Fortunately, your interviewer doesn't expect that. Virtually everyone has some bugs or minor syntactical errors.

The nice thing about a whiteboard is that, in some ways, you can focus on the big picture. You don't have a compiler, so you don't need to make your code compile. You don't need to write the entire class definition and boilerplate code. You get to focus on the interesting, "meaty" parts of the code: the function that the question is really all about.

That's not to say that you should just write pseudocode or that correctness doesn't matter. Most interviewers aren't okay with pseudocode, and fewer errors are better.

Whiteboards also tend to encourage candidates to speak more and explain their thought process. When a candidate is given a computer, their communication drops substantially.

But it's not for everyone or every company or every situation.

The above sections are intended to help you understand the thought process of the company.

My personal thoughts? For the right situation, when done well, it's a reasonable judge of someone's problem-solving skills, in that people who do well tend to be fairly smart.

However, it's often not done very well. You have bad interviewers or people who just ask bad questions.

It's also not appropriate for all companies. Some companies should value someone's prior experience more or need skills with particular technologies. These sorts of questions don't put much weight on that.

It also won't measure someone's work ethic or ability to focus. Then again, almost no interview process can really evaluate this.

This is not a perfect process by any means, but what is? All interview processes have their downsides.

I'll leave you with this: it is what it is, so let's do the best we can with it.

► How Questions are Selected

Candidates frequently ask what the "recent" interview questions are at a specific company. Just asking this question reveals a fundamental misunderstanding of where questions come from.

At the vast majority of companies, there are no lists of what interviewers should ask. Rather, each interviewer selects their own questions.

Since it's somewhat of a "free for all" as far as questions, there's nothing that makes a question a "recent Google interview question" other than the fact that some interviewer who happens to work at Google just so happened to ask that question recently.

The questions asked this year at Google do not really differ from those asked three years ago. In fact, the questions asked at Google generally don't differ from those asked at similar companies (Amazon, Facebook, etc.).

There are some broad differences across companies. Some companies focus on algorithms (often with some system design worked in), and others really like knowledge-based questions. But within a given category of question, there is little that makes it "belong" to one company instead of another. A Google algorithm question is essentially the same as a Facebook algorithm question.

► It's All Relative

If there's no grading system, how are you evaluated? How does an interviewer know what to expect of you?

Good question. The answer actually makes a lot of sense once you understand it.

Interviewers assess you relative to other candidates on that same question by the same interviewer. It's a relative comparison.

For example, suppose you came up with some cool new brainteaser or math problem. You ask your friend Alex the question, and it takes him 30 minutes to solve it. You ask Bella and she takes 50 minutes. Chris is never able to solve it. Dexter takes 15 minutes, but you had to give him some major hints and he probably would have taken far longer without them. Ellie takes 10—and comes up with an alternate approach you weren't even aware of. Fred takes 35 minutes.

You'll walk away saying, "Wow, Ellie did really well. I'll bet she's pretty good at math." (Of course, she could have just gotten lucky. And maybe Chris got unlucky. You might ask a few more questions just to really make sure that it wasn't good or bad luck.)

Interview questions are much the same way. Your interviewer develops a feel for your performance by comparing you to other people. It's not about the candidates she's interviewing *that* week. It's about all the candidates that she's *ever* asked this question to.

For this reason, getting a hard question isn't a bad thing. When it's harder for you, it's harder for everyone. It doesn't make it any less likely that you'll do well.

► Frequently Asked Questions

I didn't hear back immediately after my interview. Am I rejected?

No. There are a number of reasons why a company's decision might be delayed. A very simple explanation is that one of your interviewers hasn't provided their feedback yet. Very, very few companies have a policy of not responding to candidates they reject.

If you haven't heard back from a company within 3 - 5 business days after your interview, check in (politely) with your recruiter.

Can I re-apply to a company after getting rejected?

Almost always, but you typically have to wait a bit (6 months to a 1 year). Your first bad interview usually won't affect you too much when you re-interview. Lots of people get rejected from Google or Microsoft and later get offers from them.



Behind the Scenes

Most companies conduct their interviews in very similar ways. We will offer an overview of how companies interview and what they're looking for. This information should guide your interview preparation and your reactions during and after the interview.

Once you are selected for an interview, you usually go through a screening interview. This is typically conducted over the phone. College candidates who attend top schools may have these interviews in-person.

Don't let the name fool you; the "screening" interview often involves coding and algorithms questions, and the bar can be just as high as it is for in-person interviews. If you're unsure whether or not the interview will be technical, ask your recruiting coordinator what position your interviewer holds (or what the interview might cover). An engineer will usually perform a technical interview.

Many companies have taken advantage of online synchronized document editors, but others will expect you to write code on paper and read it back over the phone. Some interviewers may even give you "homework" to solve after you hang up the phone or just ask you to email them the code you wrote.

You typically do one or two screening interviews before being brought on-site.

In an on-site interview round, you usually have 3 to 6 in-person interviews. One of these is often over lunch. The lunch interview is usually not technical, and the interviewer may not even submit feedback. This is a good person to discuss your interests with and to ask about the company culture. Your other interviews will be mostly technical and will involve a combination of coding, algorithm, design/architecture, and behavioral/experience questions.

The distribution of questions between the above topics varies between companies and even teams due to company priorities, size, and just pure randomness. Interviewers are often given a good deal of freedom in their interview questions.

After your interview, your interviewers will provide feedback in some form. In some companies, your interviewers meet together to discuss your performance and come to a decision. In other companies, interviewers submit a recommendation to a hiring manager or hiring committee to make a final decision. In some companies, interviewers don't even make the decision; their feedback goes to a hiring committee to make a decision.

Most companies get back after about a week with next steps (offer, rejection, further interviews, or just an update on the process). Some companies respond much sooner (sometimes same day!) and others take much longer.

If you have waited more than a week, you should follow up with your recruiter. If your recruiter does not respond, this does *not* mean that you are rejected (at least not at any major tech company, and almost any

other company). Let me repeat that again: not responding indicates nothing about your status. The intention is that all recruiters should tell candidates once a final decision is made.

Delays can and do happen. Follow up with your recruiter if you expect a delay, but be respectful when you do. Recruiters are just like you. They get busy and forgetful too.

► The Microsoft Interview

Microsoft wants smart people. Geeks. People who are passionate about technology. You probably won't be tested on the ins and outs of C++ APIs, but you will be expected to write code on the board.

In a typical interview, you'll show up at Microsoft at some time in the morning and fill out initial paper work. You'll have a short interview with a recruiter who will give you a sample question. Your recruiter is usually there to prep you, not to grill you on technical questions. If you get asked some basic technical questions, it may be because your recruiter wants to ease you into the interview so that you're less nervous when the "real" interview starts.

Be nice to your recruiter. Your recruiter can be your biggest advocate, even pushing to re-interview you if you stumbled on your first interview. They can fight for you to be hired—or not!

During the day, you'll do four or five interviews, often with two different teams. Unlike many companies, where you meet your interviewers in a conference room, you'll meet with your Microsoft interviewers in their office. This is a great time to look around and get a feel for the team culture.

Depending on the team, interviewers may or may not share their feedback on you with the rest of the interview loop.

When you complete your interviews with a team, you might speak with a hiring manager (often called the "as app", short for "as appropriate"). If so, that's a great sign! It likely means that you passed the interviews with a particular team. It's now down to the hiring manager's decision.

You might get a decision that day, or it might be a week. After one week of no word from HR, send a friendly email asking for a status update.

If your recruiter isn't very responsive, it's because she's busy, not because you're being silently rejected.

Definitely Prepare:

"Why do you want to work for Microsoft?"

In this question, Microsoft wants to see that you're passionate about technology. A great answer might be, "I've been using Microsoft software as long as I can remember, and I'm really impressed at how Microsoft manages to create a product that is universally excellent. For example, I've been using Visual Studio recently to learn game programming, and its APIs are excellent." Note how this shows a passion for technology!

What's Unique:

You'll only reach the hiring manager if you've done well, so if you do, that's a great sign!

Additionally, Microsoft tends to give teams more individual control, and the product set is diverse. Experiences can vary substantially across Microsoft since different teams look for different things.

Amazon.com's #1 Best-Selling Interview Book

CRACKING *the* CODING INTERVIEW

I am not a recruiter. I am a software engineer. And as such, I know what it's like to be asked to whip up brilliant algorithms on the spot and then write flawless code on a whiteboard. I've been through this—as a candidate and as an interviewer.

Cracking the Coding Interview, 6th Edition is here to help you through this process, teaching you what you need to know and enabling you to perform at your very best. I've coached and interviewed hundreds of software engineers. The result is this book.

Learn how to uncover the hints and hidden details in a question, discover how to break down a problem into manageable chunks, develop techniques to unstuck yourself when stuck, learn (or re-learn) core computer science concepts, and practice on 189 interview questions and solutions.

These interview questions are real; they are not pulled out of computer science textbooks. They reflect what's truly being asked at the top companies, so that you can be as prepared as possible.

WHAT'S INSIDE?

- 189 programming interview questions, ranging from the basics to the trickiest algorithm problems.
- A walk-through of how to derive each solution, so that you can learn how to get there yourself.
- Hints on how to solve each of the 189 questions, just like what you would get in a real interview.
- Five proven strategies to tackle algorithm questions, so that you can solve questions you haven't seen.
- Extensive coverage of essential topics, such as big O time, data structures, and core algorithms.
- A "behind the scenes" look at how top companies, like Google and Facebook, hire developers.
- Techniques to prepare for and ace the "soft" side of the interview: behavioral questions.
- For interviewers and companies: details on what makes a good interview question and hiring process.



GAYLE LAAKMANN MCDOWELL

Gayle Laakmann McDowell is the founder and CEO of CareerCup and the author of *Cracking the PM Interview* and *Cracking the Tech Career*.

Gayle has a strong background in software development, having worked as a software engineer at Google, Microsoft, and Apple. At Google, she interviewed hundreds of software engineers and evaluated thousands of hiring packets as part of the hiring committee. She holds a B.S.E. and M.S.E. in computer science from the University of Pennsylvania and an MBA from the Wharton School.

She now consults with tech companies to improve their hiring process and with startups to prepare them for acquisition interviews.

6TH
EDITION

ISBN 978-0-9847828-5-7



9 780984 782857