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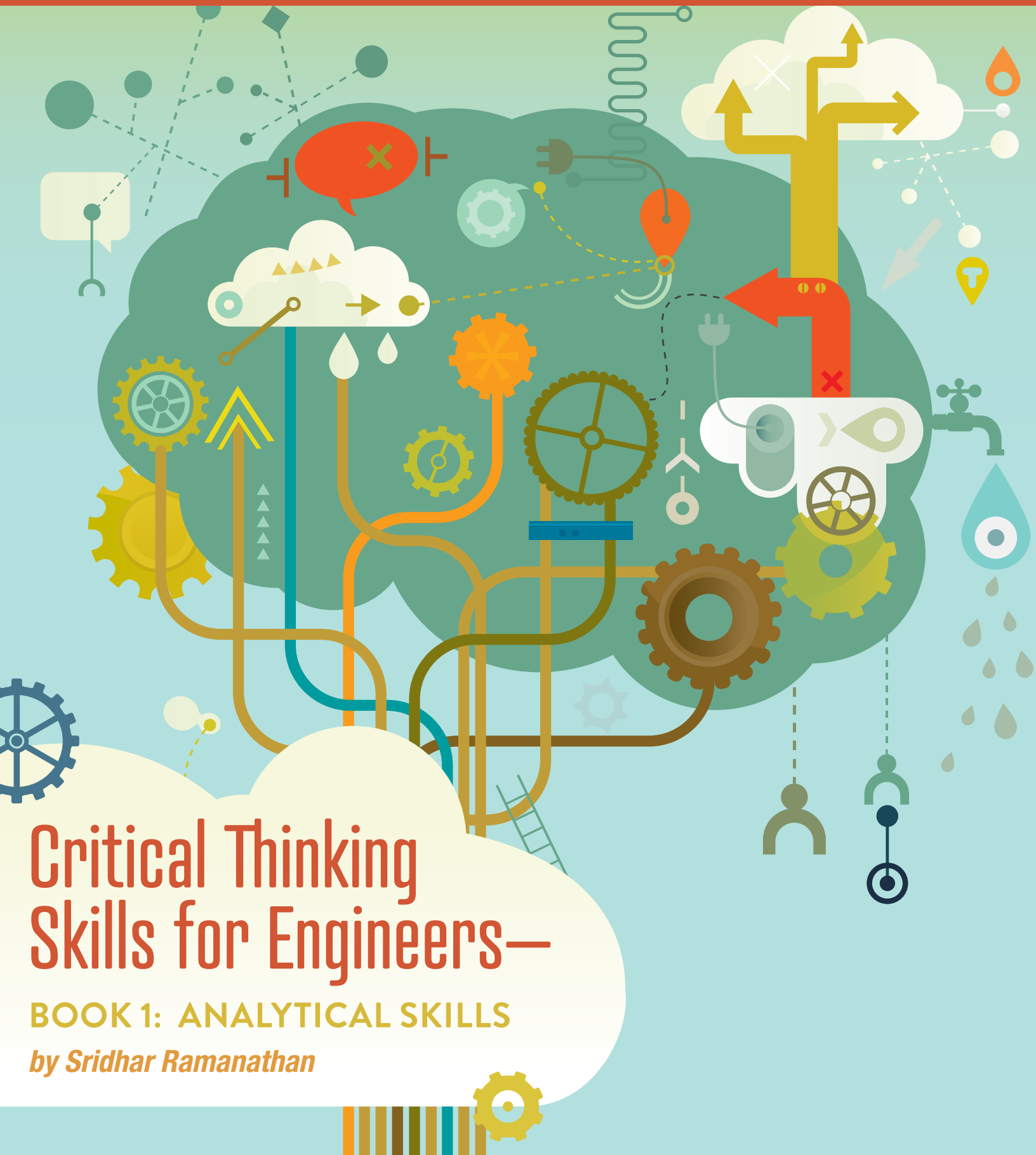

Critical Thinking Skills for Engineers—

BOOK 1: ANALYTICAL SKILLS

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IEEE★USA

To Gina, my soul mate, best friend, and ever-loving wife.

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INTRODUCTION

We live in times when facts, claims, opinions, and even data are vying for our attention—ultimately aiming to drive us to some desired action—to purchase something, go somewhere, vote for someone, experience something, build something, etc. If we're not careful, we are acting on someone else's best interests—not necessarily your own. And if you are an engineer, or in a technical field, then critical thinking is all the more important to delivering the most effective and potentially novel, break-through solution you can. In this book series, we explore the key aspects of critical thinking: analytical skills, data analysis, interpretation, judgment, questioning evidence, recognizing similarities and differences, creativity, communication, and skepticism.

In this first book, we delve into analytical skills—the ability to examine something carefully—whether it is a problem, a set of data, or text. People with analytical skills can examine information, and then understand what it means, and what it represents. And that aptitude allows for much richer, better solutions to real-world challenges. Let's start now with the elements of analytical thinking.

ASKING THOUGHTFUL QUESTIONS

Charles Kettering, the head of research for GM, once said: "A problem well-stated is half-solved."[1] Therefore, it's critical to ask the right questions, so you focus engineers/staff on solving the right problem(s). Let's use an example to explore how to frame thoughtful questions.

A smartphone manufacturer's marketing department tells their VP of Engineering that consumers complain they have to re-charge their phones way too often. She asks her team, "How can we increase the battery capacity by 25 percent?"

Before engineers leap to answer that question, it's helpful first to ask why it's important to increase battery capacity. You'll soon find that the real need is actually reduced time between charges—and that certainly one way to achieve that, is by increasing battery capacity. Instead of framing the question so narrowly on battery capacity, the VP might have asked "How do we extend the time between battery re-charges by 25 percent?"

Engineers and their managers should generate a few more "how" and "why" questions that point to possible solutions, or even unexpected breakthroughs. For example:

- Why is increasing battery capacity the best solution to reducing re-charge times? Why is 25 percent the right goal, versus something even bolder, like 100 percent? What breakthrough would we have to achieve to double the lifetime?
- Why are applications and systems processes consuming so much power?
- How should we optimize mobile applications to conserve battery usage?
- How should we optimize system processes, or even defer their activation, to save power?
- How can we encourage users to make small tweaks (e.g., turning down the brightness, deleting unused apps, etc.) that save power?
- How can we improve the efficiency of the battery itself to hold charges longer?

1 https://www.brainyquote.com/quotes/charles_kettering_181210

- How are other important factors affecting the length of time a battery holds its charge?

- How can our battery supplier squeeze out longer storage times?

- Why couldn't we use the phone itself to generate power (e.g., maybe a thin solar cell on the back)?

- As you can see, by dramatically expanding the line of questions beyond just battery capacity, the VP of Engineering is casting a much wider net for capturing potentially more elegant and far-reaching solutions.

Tip: Ask at least ten questions—especially starting with "why" and "how," when someone presents you with an engineering challenge.