# Computer Science Foundations
# Puzzle-Solving Workshop and Seminar
### Episode 9—December 2
### Fall 2013

### Paul Pham and Neal Nelson

### December 2, 2013

Welcome to the Puzzle-Solving Workshop and Seminar for Computer Science Foundations. You will notice there are two parts to this thread: *workshop* and *seminar*. Workshop is meant to strengthen your problem-solving skills, to help you in the Discrete Math thread as well as future math and computer science courses. Seminar is meant to work on your discussion, writing, and creativity skills. We will alternate between the two different modes.

## 1   Friends When You Need Them

Elise has invited Carl and Ada over to her house to work on their homework. Carl, wanting to spend time alone with Ada, but not sure how to get rid of Elise, reluctantly agreed. They are sitting in the garage, where each of them has set up their own ideal work environment. Carl is standing by a chalkboard covered in equations, working out his discrete math homework in a mathematically elegant and rigorous way. Ada sits at a bench, hammering and forging and soldering the parts to her pet computer, which she calls Sparky. When it's finished, Sparky will run Python programs and help her finish her programming homework.

Elise slumps in a beanbag chair on the ground, sketching doodles in her notebook with a thick black pen. The doodles are a storyboard for her new zine, which she will take to the comics store to sell when she's done. If we were to peek over her shoulder, we would discover that Ada, Carl, and Elise are themselves characters in her graphic novel, having adventures, mostly related to discrete math, computer programming, and puzzle-solving.

"Hey honey, I brought you and your friends sandwiches," her dad says, poking his head through the garage door. "I thought you might be hungry."

"Thanks, Dad, you're the best," Elise says, getting up to hug her dad.

"Yeah, thanks Mr. de Morgan," both Carl and Ada say as they dig into the sandwiches. "Math is hard."

"Well, I'm just glad Elise finally has some friends. It's been lonely for her since her mother died. For both of us." Mr. de Morgan pats his daughter on the head and turns to her friends. "I rest a little easier knowing she can rely on you two."

Carl and Ada exchange a confused look before turning back. "Er, yeah, we'll totally help Elise pass this discrete math class."

"Dad, stop being weird, you're embarrassing me," Elise pretends to be angry before shooing her dad out. "Sorry guys, he always makes a big deal when I bring friends home."

## 2   Perfect Numbers

"I'm stuck—" Carl finally says, turning to Ada. Always surprised by her beauty, he stammers for a bit, trying not to stare like a creep. Ada, however, is also vainly admiring her reflection in one of Sparky's polished sideplates, smiling at herself. "Um, er, do you know anything about perfect numbers?"

"Hmm? No, but I do like things that are perfect." Ada turns to face him, twirling her hair around a finger. "Tell me about them."

> A perfect number is a positive integer which is equal to the sum of all of its factors (divisors), including 1 but not itself. As an example, the first perfect number is $6 = 1 + 2 + 3$.

"But I can't find a formula for finding arbitrarily many perfect numbers," Carl says.

"You don't need a formula. You just need to write a program." Ada finishes screwing in her computer's sideplates. "Sparky could do it for you. I just have to write a Python program first."

She flips a switch, and Sparky whirs to life. He clacks and spins and grrs and barks with pseudo-lifelike precision. "Woof," he blurts out. Ada pats him on the head. "Good boy."

**Problem 1** Write a Python program to check the numbers from 1 to 100,000 to determine if any of them are perfect numbers. Print out the numbers that *are* perfect. If you don't know Python, use the pseudo-code described in Section 3.1 of your discrete math textbook by Rosen. Then partner up with someone who does know Python to run the program and check your work.

Run your program on Sparky (er, or on a website such as PythonAnywhere or repl.it).

## 3   A Mystery of Sorts, in the Library

All of a sudden, a loud crash interrupts them from upstairs. Exchanging an alarmed glance, the four of them drop their chalk / screwdriver / notebook /

bolts and dash upstairs to discover the source of the noise.

"Dad?" Elise calls out loudly, almost in a panic, as they search the house for her father. "Dad?!"

"Bark," says Sparky.

"Of course, Sparky! Here, in the library," Ada says calmly, noticing the open door and the sound of fluttering pages through it. Upon entering the room full of books, they find a broken window, the curtains billowing in the wind. Several tables and chairs are knocked over, with books scattered on the ground, as if a great struggle occurred. A leather armchair sits next to the still roaring fireplace, where Elise's father was fond of sitting. On the endtable, an open book has pages fluttering in the wind. While Carl and Ada scout the room looking for clues, Elise picks up her father's pipe, which is marking a place in the book.

"Oh no..." Elise breathes in fear, as Carl and Ada gather around. There on the page, in rushed handwriting, is a note:

> My dearest Elise,
>
> As you know, I have long suspected that the computers and robots in our world are becoming more networked, more controlled by a sinister power which I have come to call the One Machine. Its agents may be everywhere, looking for me now. If you cannot find me, I have left to protect you. Do not try to find me, it is too—

Here the note ends in a scrawled line that drags to the edge of the page, and they find a fountain pen on the ground.

"He always thought this might happen. He even made up a secret code that only the two of us knew about. I'd never thought we'd have to use it." Elise finishes reading the note, her hands falling down in despair. "We *have* to go after him."

"But... but your father explicitly said not to," Carl reminds her nervously. "He was going to say the word *dangerous* next, I'm sure of it." He gestured to the broken furniture. "Look, there was a fight between your father and the agents of the One Machine."

"No, that was part of our code. When he says not to come after him, he means the exact opposite!" Elise is about to cry. "But I can't do this alone, guys. I'm scared." For some reason, both she and Carl look to Ada next to see what she will do.

"I agree with Carl," Ada says at last, which gave him a gratified look. "Based on this apparent struggle, it looks like Mr. de Morgan was kidnapped or forced to flee. This will indeed be dangerous." Carl nods vigorously. She examines the note. "I also agree with Elise," which causes Carl to frown a little. "We should go after him."

"Oh thank you!" Elise hugs Ada suddenly. Then they both pause awkwardly and withdraw, but with slight smiles.

"Ahem!" Carl interrupts them. "All right, I'll go with you. I'm sure you'd do the same for me, although *my* father is much too smart to get mixed up

with sinister, all-powerful sentient computers. So how do we find him?"

"Each of the books in my father's library has a volume number. He said he would write one letter inside the front cover of each book, when they're all in order, telling me where to find him. But they're all scattered around the floor! They'll take forever to sort."

"Not necessarily. We've been learning sorting algorithms in discrete math class. I'll program Sparky to simulate which one would be the fastest for us."

Sparky wags his robotic tail.

Listed below are the volume numbers of the books lying scattered on the library floor, along with the single letter written on the inside of each book's cover. The volume number is shown before the colon and the letter is shown after the colon, in each pair, or *item*. There are 35 items altogether. Note that this is not exactly a Python dictionary, because order matters here (remember, this is the physical order of the books as they would look on the floor to our characters.)

```
 6:t 30:l 5:f 27:e 12:s 34:s 24:t 32:n 25:i 10:e 8:e 20:n
17:r 33:d 21:d 3:p 1:h 28:i 15:w 22:u 2:i 26:v 7:h 19:i 14:o
16:a 9:s 23:c 29:s 0:s 4:o 18:d 11:u 31:a 13:t
```

Write a Python program to sort this list using bubble sort and insertion sort given in pseudo-code in your Rosen textbook (Chapter 3), and then run it on Sparky (again, PythonAnywhere or repl.it. At least, until you can build your own robotic dog that understands Python.)

**Problem 2** How many comparisons (between two items) will be necessary to fully sort the list using bubble sort?

**Problem 3** How many comparisons (between two items) will be necessary to fully sort the list using insertion sort?

**Problem 4** What is the scrambled message encoded by these letters? That is, where should Ada, Elise, and Carl go to find Mr. de Morgan?