

# Introduction to Scientific Computing Languages

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The computers of the submarine U-96 used a 10-bit arithmetic:

$$\beta = 2, \quad t = 7, \quad e_{\min} = -3, \quad e_{\max} = 4.$$

The arithmetic did not include NaNs, infinities, overflows, and such. The three-digit exponent identifies the integers  $[0, \dots, 7]$ , which logically map to  $[-3, \dots, 4]$ .

During one of her trips, the U-96 suffered from what is known as the “bits-switch bug”: The values of two bits (even non-adjacent ones) were exchanged. For instance, as a result of the bug, the number  $[0101010, 101]$  could turn into  $[1101010, 100]$ .

The objective of this challenge is to characterize the set of numbers resulting from the bits-switch bug, when it occurs in the binary representation of the constant  $e$ .

- Let  $e_{U96}$  be the representation of  $e$  in the U-96 floating point arithmetic.
- Consider  $\mathcal{S}$ , the set containing all the possible numbers (representations) resulting directly from a bits-switch of  $e_{U96}$ , **except**  $e_{U96}$  itself.  
Note: do not consider the bits-switches of a bits-switch.

- **Questions:**

- [0.] What is the machine precision for the U-96 arithmetic?
- [1.] How many different numbers are in  $\mathcal{S}$ ?
- [2.] What is the largest number in  $\mathcal{S}$ ? (★)
- [3.] What is the smallest number in  $\mathcal{S}$ ? (★)
- [4.] Among the numbers in  $\mathcal{S}$ , what is the best representation for  $e$ ? (★)  
What is the corresponding relative error?
- [5.] Among the numbers in  $\mathcal{S}$ , which two are the closest to  $e$ ? (★)

(★): Both in binary and in base 10.

# Rules

The first student who submits the right answer wins the challenge. However, there might be more than one winner.

- Individual assignment
- Submit both the final answers and their derivation
- Submission by email to `pauldj@aices.rwth-aachen.de`
- Email's subject: “[LSC-18] Challenge1 <your last name>”
- Accepted formats: plain text, pdf
- If you send an attachment, name the file `<your name>.txt` or `<your name>.pdf`
- I will not answer any questions until the challenge is over. If any issue arises (bug found, clarification needed, ...), I will send a collective email
- **Deadline: The challenge is open until further notification.**