1. TOY has \( \boxed{16} \) registers, numbered \( R[0] \) through \( R[F] \).

2. One of these registers is special. Which is it? \( R[0] \) What makes it special?

   \[ R[0] \text{ always has the value } 0. \]

3. TOY has \( \boxed{256} \) memory locations, addressed \( 00 \) through \( FF \).

4. One of these memory locations is special. Which is it? \( FF \) What makes it special?

   \[ \text{We write to } FF \text{ to use StdOut and read from } FF \text{ for StdIn}. \]

5. TOY has \( \boxed{16} \) op codes, numbered \( 0 \) through \( F \).

6. TOY has one PC. What does “PC” stand for? \( \text{Program Counter} \)

7. What does the PC do?

   \[ \text{The PC keeps track of the address of the next instruction to be executed} \]

8. Use the TOY cheatsheet to fill in the following blanks:

\[
\begin{array}{|c|c|c|c|}
\hline
\text{MEM} & \text{CODE} & \text{PSEUDO-CODE} & \text{HUMAN-READABLE COMMENTS} \\
\hline
10: & 7101 & R[1] \leftarrow 01 & R[1] \text{ gets the constant } 1 \\
12: & 7301 & R[3] \leftarrow 01 & R[3] \text{ gets the constant } 1 \\
13: & 85FF & R[5] \leftarrow \text{mem}[FF] & \text{Read N from StdIn } (R[5]) \\
17: & 2551 & R[5] \leftarrow R[5] - R[1] & \text{Subtract } 1 \text{ from } N \ (R[5]) \\
18: & 5514 & \text{if } (R[5]>0) \text{ pc<-14} & N > 0? \text{ Do another iteration.} \\
19: & 94FF & \text{mem}[FF] \leftarrow R[4] & \text{Send the sum in } R[4] \text{ to StdOut} \\
1A: & 0000 & \text{halt} & \text{When we get here, we’re done!} \\
\hline
\end{array}
\]
9. List 6 TOY instructions, each having a different op code, that copy the value of R[B] into R[A].

   1AB0, 2AB0, 3ABB, 4AB0, 5AB0, 6AB0

10. List 7 TOY instructions, each having a different op code, that put 0000 in R[A].

   1A00, 2A00, 3A00, 4A00, 5A00, 6A00, 7A00

11. Write a TOY program that sets R[B] to the absolute value of R[A]. (Can be done in 4 or 5 lines.)

   MEM  CODE  PSEUDO-CODE                                           HUMAN-READABLE COMMENTS
   10:  DA13   if (R[A]>0) pc<-13           if R[A]>0 go to R[B]<-R[A]
   12:  C014   if (R[0]==0) pc<-14          then go directly to halt
   14:  0000   halt                           All done!

12. Consider the following TOY program. What is the value of R[3] when it halts? 128

   MEM  CODE  PSEUDO-CODE                                           HUMAN-READABLE COMMENTS
   15:  D213   if (R[2]>0) pc<-13         if (R[2]>0) go to 13
   16:  0000   halt                         Done!

   Stored as 0080 in memory, because all TOY data is stored in hex, not decimal.

Can you trace this four line solution?
10: 1BA0
11: DB13
12: 2B0B
13: 0000