1. Show that the following program fragment, with precondition \( i = 1 \land \text{sum} = 0 \land n \geq 1 \), terminates:

\[
\text{while } (i <> n) \text{ do}
\begin{align*}
&\text{begin} \\
&\quad \text{sum} := \text{sum} + i; \\
&\quad i := i + 1 \\
&\text{end}
\end{align*}
\]

**Answer:** Consider the quantity \( n - i \), where we indentify the names of variables with their values. This quantity starts nonnegative, because the precondition \( i = 1 \land \text{sum} = 0 \land n \geq 1 \) entails \( n - i \geq 0 \) at the beginning of the loop. This quantity always decreases as the body of the loop is executed, because \( i \) increases by one, while \( n \) remains the same. This quantity never becomes negative, because the loop body is executed only if \( n <> i \). So, as the program executes, \( n - i \) decreases monotonically, and \( n - i \) cannot become negative. Therefore, the program must stop executing.

2. Do you know what a loop invariant is? (Please answer yes or no.)

**Answer:** There is no correct answer. About 30 out of 35 students answered no.