1. Let E be the expression $n - i$. With each iteration of the loop `i` increases by 1. Therefore $n - i$ decreases by 1 with each pass. Eventually E will be negative, and the loop will terminate. In particular, when $n - i \leq -1$.

We prove the following statement by induction on the value of the variable `i`.

STATEMENT $S(m)$: If we reach the loop test $i \leq n$ with the variable `i` having the value m, then the value of the variable `sum` is $\sum_{k=1}^{m-1} k$.

BASIS. The basis is $m = 1$. When we first enter the loop we reach the test with `i` having value 1 and `sum` having value 0. We see that $\sum_{k=1}^{0} k$ is surely 0. So the basis is proven.

INDUCTION. Assume $S(m)$. We shall prove $S(m+1)$.

We assume here that we are not entering the loop for the first time. If $m > n$, then when `i` has the value m we do not reach the loop test. Thus with `i` having the value $m+1$, we do not reach the loop test. In that case $S(m+1)$ is trivally true.

If $m \leq n$, then we consider what happens when we execute the body of the loop with `i` having the value m. By the inductive hypothesis, `sum` has value $m(m-1)/2$ and `i` has value m (yes we repeat that `i` has value m again). After the body of the loop is executed, and when we reach the loop test, `sum` has the value $\sum_{k=1}^{m} k = m(m+1)/2$ and `i` has the value $m+1$. We have proven $S(m+1)$, therefore $S(m)$ holds for $m \geq 1$.

We expressed earlier that the loop will terminate when $n - i \leq -1$. That is, when `i` has the value $n+1$. Thus after the body terminates $S(n+1)$ must hold, because we reach the test loop when `i` has at most the value $n+1$. This statement says that `sum` has the value $\sum_{k=1}^{n} k$, which is the desired result of the program. ✦