Let the variables be $x, y: int$. Write a program to refine specification $\neg ok$. Prove your refinement.

Let $n$ and $d$ be $nat$ variables. Here is a refinement.

$$n' = n + d \times (d - 1)/2 \iff$$

- if $d = 0$ then $ok$ else $d := d - 1$. $n := n + d$. $n' = n + d \times (d - 1)/2$ fi

(a) Insert appropriate time increments according to the recursive measure, and write an appropriate timing specification and refinement.

(b) Using your timing specification from part (a), prove the timing refinement.

Let $x$ and $y$ be integer variables, and let $L$ be a list of integers. What is the exact precondition for $\exists y \cdot L y < x'$ to be refined by $x := y + 1$?

The specification

$$\text{var } x: nat \quad x := -1$$

introduces a local variable and then assigns it a value that is out of bounds. Is this specification implementable? (Proof required.)