Solution to Problem 17

Problem. Use the impossibility of zero-checker (that we proved in class) to prove that no algorithm is possible that, given a program p that always halts, checks whether this program always computes $n^2 + n$.

Solution. We will prove that if such a checker exists, then we can construct a zero-checker – and we already know that zero-checkers are not possible. Indeed, let us assume that we have an algorithm $checker(p)$ that, given a program p that always halts, checked whether $\forall n\,(p(n) = n^2 + n)$. Suppose that we have a program q that always halts and we want to check whether this program q always returns 0. To check this, we form the following auxiliary program that always returns $q(n) + n^2 + n$:

```
public static int aux(int n)
  {return q(n) + n * n + n;}
```

The value $q(n) + n^2 + n$ is always equal to $n^2 + n$ if and only if the value $q(n)$ is always equal to 0.

Thus, the algorithm $checker(q(n)+n^2+n)$ that applies *checker* to the above auxiliary program is a zero-checker. However, we have proven that zero-checkers do not exist. This contradiction shows that our assumption – that the desired checkers are possible – leads to a contradiction. Thus, such checkers are not possible. The theorem is proven.