

Answer

On this question as stated, essentially all the examinees stated that they believed (useful) computing without any dissipated power or energy was impossible (and, indeed, it is not possible to do useful computing, as defined later to the examinees, without dissipation of energy).

Most examinees were not initially clear exactly why a computer had to dissipate energy for a useful calculation, other than that they could not imagine computing parts that did not dissipate. Some students knew that the action of a logic gate, such as an AND gate, necessarily involves some dissipation because it is not reversible; knowing the output of an AND gate is not sufficient to tell you what the inputs had been.

There are, at least in principle, ways of performing computations without dissipating any energy. Some students knew that there have been proposals for reversible logic that does not throw away any information. (The Controlled-NOT gate of quantum computing is one such gate. Classical reversible gates were considered some years ago (e.g., by Fredkin and Toffoli) that also do not throw away information.) It is also true that ordinary analog physical systems, such as two balls bouncing elastically off one another, could be viewed as performing calculations of results without any particular dissipation; as an analog computer, such a system does obviously compute the result of two balls bouncing off of one another. But there is a catch in all such reversible systems, which relates to the idea of a useful calculation. At this point in the exam, after some discussion on points like these, the examinees were verbally asked the following question.

Question (second part)

A computation here will not be considered useful unless the result of the calculation is written down somewhere, such as in a memory register of some kind (e.g., in a USB memory stick). Given that requirement, and given a result that will be of some specific length (e.g., a 10 bit binary number), is there some lower bound to the amount of energy that must be dissipated for the computation to give a useful answer?