Approximating the value of expressions

1. What are some of the reasons for assuming that we will be sampling at equally spaced points in space or time? That is, why can we generally assume that $x_k = x_0 + kh$ or $t_k = t_0 + k\Delta t$?

Answer: Engineers will generally design systems that are to be both efficient and responsive but also easy to design and analyze.

If samples are taken periodically, then formulas are often simplified and are also predictable (the responses are not dependent on the sampling rate). For real-time systems, the scheduling of when sensor readings occur can be accounted for much more easily if the readings are periodic. Thus, the response of the system can be more easily predicted at any time.

If you have different sampling rates at different times, you will be analyzing the response of your system at each sampling rate, so if there are only two different sampling rates, this may still be reasonable, but you must also ensure that the algorithms are in place to ensure that the appropriate sampling rate is occurring at the appropriate time. If, however, you have non-uniform sampling rates, many of the formulas become much more complex, and the response will be much more difficult to analyze.

It may be possible to have samplings that are not periodic in either space or time, but often in deployed engineering solutions, the extra work necessary to accomplish this is not worth the effort, as this is likely to require more computational effort which, in itself, requires additional work.

Incidentally, in this course, we will look at one case (the adaptive Euler-Huen and Dormand-Prince methods) where we do not sample values periodically, but that is used to approximate a solution to ordinary differential equations, something that is nominally used in the deployed systems, but rather in the development phase. Similarly, engineers working with moving and flexible materials may employ finite-element methods to better simulate such materials.