PART I

AREAS OF APPLICATION

Downloaded from https://www.cambridge.org/core. UNIVERSIDAD AUTONOMA METROPOLITANA, on 16 Nov 2026 at 21:07:40, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/9781009639651.002

Downloaded from https://www.cambridge.org/core. UNIVERSIDAD AUTONOMA METROPOLITANA, on 16 Nov 2026 at 21:07:40, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/9781009639651.002

Overview

To provide benefit, quantum computers must solve computational problems where the solutions are simultaneously valuable to the user and also difficult to obtain classically. Simply developing a quantum algorithm with a theoretical quantum speedup is not sufficient to meet these criteria; we must directly compare the performance of classical and quantum algorithms for concrete problems of interest.

In this part, we survey a number of specific computational problems where quantum algorithms have been proposed, organized by application area. We present an overview of these algorithms through an end-to-end lens, noting clearly the actual end-to-end problem that is being solved and the dominant resource cost/complexity (derived from the algorithmic primitives that are being used), and emphasizing noteworthy caveats. We list known resource estimates for implementing these algorithms on fault-tolerant quantum computers (we also comment in passing on NISQ implementations), and we compare to classical complexities for the same problem, both in a practical and asymptotic sense. The list of applications presented is not exhaustive, but represents a broad spectrum of the most well-studied applications proposed in the literature.

Downloaded from https://www.cambridge.org/core. UNIVERSIDAD AUTONOMA METROPOLITANA, on 16 Nov 2026 at 21:07:40, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/9781009639651.002