This thesis demonstrates the application of the lattice Boltzmann method for topology optimization problems. Specifically, the focus is on problems in which time-dependent flow dynamics have significant impact on the performance of the devices to be optimized. The thesis introduces new topology optimization problems for both isothermal and thermal flows, and it is demonstrated that topology optimization can account for unsteady flow effects during the optimization process. The introduced optimization problems are solved using a gradient based approach, and the design sensitivities are computed using a discrete adjoint approach. To handle the complexity of the discrete adjoint approach more easily, a method for computing it based on automatic differentiation is introduced, which can be adapted to any lattice Boltzmann type method. For example, while it is derived in the context of an isothermal lattice Boltzmann model, it is shown that the method can be easily extended to a thermal model as well. Finally, the predicted behavior of an optimized design is compared to the equivalent prediction from a commercial finite element solver. It is found that the weakly compressible nature of the lattice Boltzmann method leads to a discrepancy in the predicted outcomes. Further research is required to determine which prediction is more accurate, and what implications the discrepancy has for the optimized designs.