Jackson, J. D.; Okun, L.B. (2001) Historical roots of gauge invariance. *Reviews of Modern Physics, 73,* 663. Retrieved from <https://journals-aps-org.proxy1.cl.msu.edu/rmp/abstract/10.1103/RevModPhys.73.663>

The most important thing to recognize with this paper is that it is primarily historical. Very little time is given to the details, such as derivations and studies of particular gauges. Rather, the paper provides a treatment of the modern development of potentials and gauges within the development of electromagnetism as a whole. Jackson notes the discoverers of important figures in the history of gauges and examples of gauges in electromagnetism prior to the formalization of the theory. In particular, Jackson cites Maxwell as having used the Coulomb gauge implicitly and Lorenz for having first noted the symmetry present in gauges, as well as using the eponymous gauge to derive a general solution to Maxwell’s equations. Weyl is cited for coining the term “gauge invariance”. Jackson also discusses the interaction of gauges and quantum mechanics, particularly with respect to the quantum electrodynamic version of the gauge transformation, with added wave equation transformation. Near the end of the paper, Jackson discusses the physical meaning of gauge invariance, in particular naming phenomena which, if discovered, would cause gauge invariance to be lost.

The first part of this paper is largely understandable; the main barrier is in understanding the cited equations. Jackson’s notation, presumably identical unless otherwise stated to the historical notation, uses a set of interweaved normal and separation vectors, which can be difficult to parse. This is made more difficult by the fact that the equations given are often unphysical for one reason or another, making it difficult to relate to known equations. Fortunately, these equations may be largely ignored for my purposes. The second part of the paper becomes more complicated. This is in part because the equations now require knowledge of quantum electrodynamics to connect to the physical world, and in part because he appears to be using Einstein notation, alongside symbols and notations commonly used in quantum electrodynamics with which I am unfamiliar. The latter should not be difficult to acquire familiarity with, should the need arise; the former may be more difficult.

Something which Jackson does not spend much time on is gauge theory from a general relativistic perspective. Here I believe is the major interest from the mathematical side of gauge invariance, so I would like to find a source which explores this more in-depth.