A wide variety of plasma waves play an important role in the energization and loss of particles in the radiation belts and ring current. Our ability to understand and model the dynamic variability of these regions requires improved knowledge of the spatial distribution and properties of these waves, and how the waves depend on changes in solar wind forcing and/or geomagnetic activity. To this end, we have developed a two-dimensional finite element code that solves the full wave equations in global magnetospheric geometry. In its current form, the code describes three-dimensional wave structure including mode conversion when ULF, EMIC, and whistler waves are launched in a two-dimensional axisymmetric background plasma with general magnetic field topology. We illustrate the capabilities of the code by examining the role of plasmaspheric plumes on magnetosonic wave propagation; mode conversion at the ion-ion and Alfvén resonances resulting from external, solar wind compressions; and wave structure and mode conversion of electromagnetic ion cyclotron waves launched in the equatorial magnetosphere, which propagate along the magnetic field lines toward the ionosphere. There are several advantages to using the finite element technique. Our mesh algorithm allows us to pack extra resolution near singular regions where mode conversion occurs—particularly useful when singular regions are ordered not only by field line but also by magnetic field strength (as near the ion-ion hybrid resonance). Another advantage is that the finite element method may be readily be adapted to solve the nonlocal integrodifferential equations that result when kinetic effects are included.