A challenging difficulty in solving the radial Dirac eigenvalue problem numerically is the presence of spurious (unphysical) eigenvalues, among the genuine ones, that are neither related to mathematical interpretations nor to physical explanations. Many attempts have been made and several numerical methods have been applied to solve the problem using the finite element method (FEM), the finite difference method, or other numerical schemes. Unfortunately most of these attempts failed to overcome the difficulty. As a FEM approach, this work can be regarded as a first promising scheme to solve the spuriosity problem completely. Our approach is based on an appropriate choice of trial and test function spaces. We develop a Streamline Upwind Petrov-Galerkin method to the equation and derive an explicit stability parameter.