# Mixed finite element methods for the Oseen problem

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## Abstract

The Oseen problem can be obtained as a linearization of the Navier–Stokes equations. The most popular formulation in computational incompressible Newtonian flows is the velocity–pressure formulation. However, for various reasons, one may need also information on the dual variables as velocity gradient. To do so, one need to build appropriate mixed formulations. The purpose of this work is to develop and analyze mixed finite element methods for the Oseen problem using the tensor gradient of velocity as a new unknown. We prove that the new variational formulation and the corresponding Galerkin scheme are well-posed. We also provide optimal order error estimates for the velocity, the pressure and the gradient of velocity when each row of the velocity gradient is approximated by Raviart–Thomas or Brezzi–Douglas–Marini elements and the velocity and the pressure are approximated by discontinuous piecewise polynomials. Moreover, for the numerical implementation, a hybrid form is presented. Finally, we include numerical experiments that support the theoretical results.