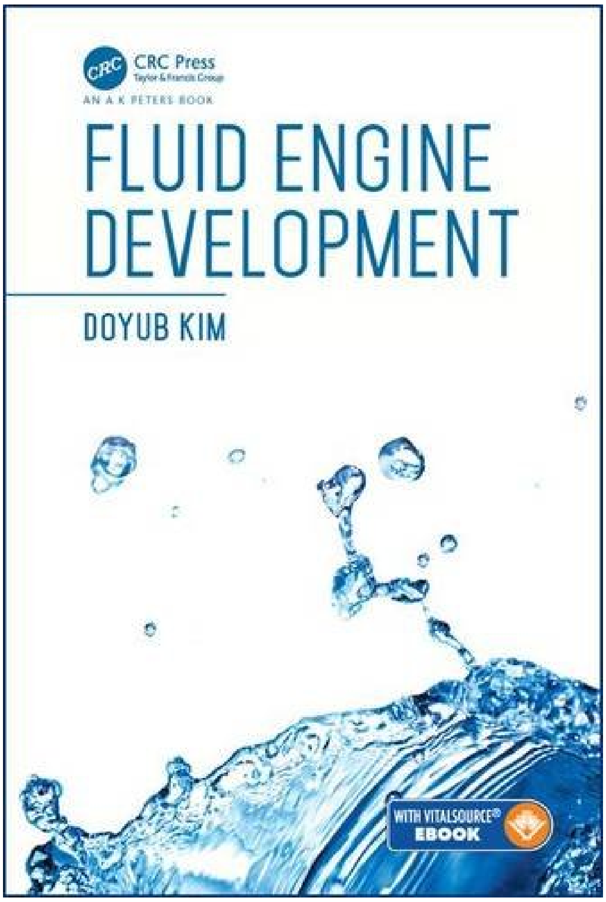
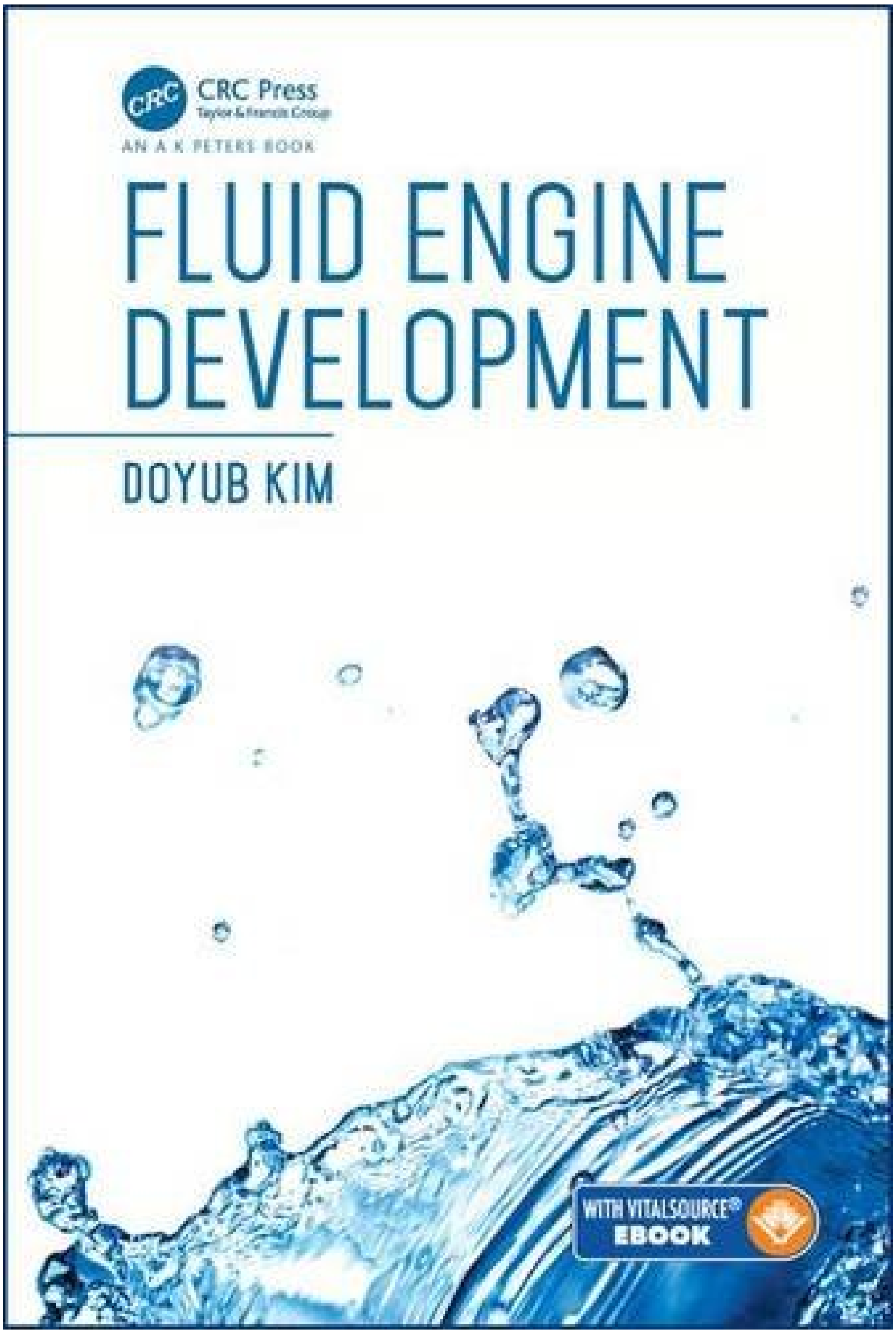
# FLUID ENGINE DEVELOPMENT BY DOYUB KIM

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About the Author

Doyub completed his B.S. and Ph.D. from Seoul National University. His doctoral research focused on physics-based animation and high-performance computing. After completing his doctoral study, he worked at Carnegie Mellon University as a post-doctoral researcher and U.C. Berkeley as a visiting researcher. Then he started his industry career at Microsoft to work on 3D maps, and later he joined Uber Maps Research team.

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From the splash of breaking waves to turbulent swirling smoke, the mathematical dynamics of fluids are varied and continue to be one of the most challenging aspects in animation. Fluid Engine Development demonstrates how to create a working fluid engine through the use of particles and grids, and even a combination of the two. Core algorithms are explained from a developer’s perspective in a practical, approachable way that will not overwhelm readers. The Code Repository offers further opportunity for growth and discussion with continuously changing content and source codes. This book helps to serve as the ultimate guide to navigating complex fluid animation and development.

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A developer friendly text featuring the elusive SPH
By Paul A. Bonyak
This text is written to be developer friendly. The code used is C++ with occasional use of some features of its latest C++11 revision so you may have occasion to refer to Bjarne Stroustrup's webpage. Explanation of the vector analysis needed and the physics is informal as the author admits. For example the author views viscosity as producing a force which tends to reduce velocity difference between neighboring points. The velocity field is therefore blurred and this blur can be produced by adding the Laplacian of the velocity field to the velocity field. Though the Laplacian may measure bumps or curvature, there's no proof here. He knew the result he had to get and essentially used that to define viscosity. That's okay though as he just wants to bring about some feel for it. He's more interested in implementing these effects in the code. Eberly's Game Physics 2nd edition is of help here especially chapter 5 on fluid dynamics. If you'd like to see an adequate

rigorous development and proof of the full Navier-Stokes equations as well as a complete explanation of viscosity see Victor Streeter's Fluid Dynamics (cheap on Amazon).
The engine is to simulate an incompressible, viscous fluid so that density is constant and the divergence of the velocity field is zero. As he is concerned with questions of convergence and stability in the code his explanation of numerical algorithms is thorough. For grid-based solution (Eulerian) he uses the finite difference method and there is no finite elements. He also uses a Lagrangian approach (particle trajectory not just within a fixed region) called smoothed particle hydrodynamics (SPH) This alone is worth the price of the book. This is fluid simulation by pointilism, Basically you take a dust of points. Regions around each point are filled with the aid of a kernel function which is used to distribute some property. Key objects are density and pressure. Pressure gradients tend to increase density and density will have to the be adjusted to maintain incompressibility. You'll find these kernels act as weighting functions for the masses of the points in determining density. In fact they're a discrete analog of green's functions which act as weights in some E&M integrals. This probably is no surprise as the method originated to simulate compressible flow in astrophysics (magnetohydrodynamics and plasmas) through the insight of Australian physicist, J.J.Monaghan. It seems kind of crazy to use this for incompressible flow but relatively few points can be used which saves computer time and expense. In short he shows and explains the code of how this method can be implemented in this case. Here you run into stuff like the Pressure Poisson equation and how to avoid as well as the predictive corrective method. He later explains hybrid methods. You'll have a pretty good feel for the material when you get through it I'm sure-maybe even enough to try compressible flow. The author maintains a site on gitHub where you can copy source code.

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