<u>Fluid Mechanics</u>

Ph.D Qualifying Exam Syllabus

Mechanical Engineering and Engineering Science

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Fluid Mechanics Committee: Drs. P. Ramaprabhu, R. Keanini and M. Uddin

The Fluid Mechanics Ph.D. qualifying exam will cover topics that are typically addressed in a graduate level, introductory course in the subject. At UNCC, the relevant courses offered by the MEES department are Advanced Fluid Mechanics and Introduction to Compressible Flow. The student is expected to display a knowledge of fluid mechanics that reflects a broad and deep understanding of fundamental concepts. The purpose of the exam is to test the student's grasp of fundamental concepts, and her ability to apply such concepts in obtaining viscous flow solutions for different boundary and initial conditions.

The exam will be closed book, while the students are allowed to bring a single (2-sided) equation sheet with essential formulae.

References:

1. Incompressible Flow, R. L. Panton, 3rd Edition, John Wiley & Sons Inc., 2005.

2. Introduction to Fluid Mechanics, R. W. Fox, A. T. McDonald & P.J. Pritchard, 6th Edition, John Wiley & Sons Inc., 2004.

3. Fundamentals of Fluid Mechanics, B.R. Munson, D.F. Young & T.H. Okiishi, 5th Edition, John Wiley & Sons Inc., 2006.

4. Physical Fluid Dynamics, D.J. Tritton, 2nd Edition, Oxford Science Publications, 1988.

Topics:

Fundamental Concepts: Continuum Hypothesis, notion of a fluid particle, Stresses in fluids, Timelines, Pathlines, Streaklines and streamlines, Classification of fluid motion, Fluid Translation (acceleration of fluid particle), fluid rotation, fluid deformation, Lagrangian/Eulerian viewpoints, Substantial derivative.

Fluid Statics: Basic law of hydrostatics, forces on submerged surfaces, Buoyancy.

Integral formulation: Control volume approach, Integral equations for conservation of mass, momentum and energy.

Differential Analysis: Fluid kinematics (motion of a fluid particle), Continuity equation, Differential momentum equations, Stream function for 2D incompressible flows.

Incompressible flow solutions: some examples are provided here - Pressure-driven flow in a duct/pipe, Plane Couette flow, Vorticity dynamics (inviscid and viscous solutions), flow around a 2D cylinder, Lift and drag on 2D shapes (Conformal transformation, Kutta condition, airfoil lift), boundary layer flow (Blasius flow over a flat plate, displacement thickness, Falkner-Skan similarity solution, boundary layer separation), High Reynolds number flows (Euler equations, Bernoulli equations).

Compressible Flow: Ideal gas relationships, Mach number and speed of sound, Isentropic flow of an ideal gas (area variation), Constant area duct flow, Converging-Diverging duct flow, Critical conditions, the Rayleigh line and corresponding flow functions for 1D flow of an ideal gas, Normal shocks (Basic equations, Normal shock flow functions for 1D flow of an ideal gas), Oblique shocks and expansion waves, Supersonic channel flow with shocks.