

VECTOR ANALYSIS & COMPLEX VARIABLES
EGR 512
Summer 2000

(Sec 01 CRN 31800, MW 1730-1920, Rm 9-429)

INTRODUCTION: Vector and scalar fields. Gradient, divergence, curl, Gauss', Green's and Stokes' Theorems. Complex functions and conformal mapping. Applications in the areas of ideal fluid dynamics and aerodynamics.

HOURS: MW 1730-1920

ROOM: 9-429

COURSE OUTLINE: Vector Analysis
Complex Variables
Ideal Fluids/Vorticity and Circulation
2-D Potential Flow
Analytic Mappings
Schwarz-Christoffel Transformations
3-D Potential Flow

PREREQUISITE: Mathematics equivalent to ABET-accredited curriculum

INSTRUCTOR: Dr. Kevin R. Anderson
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OFFICE HOURS: MW 1930-2030

TEXTBOOKS: "Advanced Engineering Mathematics" by Wylie and Barrett, 6th Edition, McGraw Hill

"Theoretical Hydrodynamics" by L.M. Mine-Thomson, 5th Edition, Dover Publications Inc.

GRADING: Problem Sets 75%
Final Exam 25%

NOTES: June 23 - Last day to drop classes without record
July 10 - Last day to drop classes without a petition

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EXTENDED COURSE OUTLINE

1. VECTOR ANALYSIS

- a) Scalar and vector products
- b) Basis vectors
- c) Covariant, contravariant vector components
- d) Curvilinear coordinates
- e) Gradient vector operator and directional derivative
- f) Divergence and curl operators
- g) Gauss's theorem
- h) Stokes' theorem
- i) Green's theorems
- j) Contour integration

2. COMPLEX VARIABLES

- a) Cartesian and polar forms: De Moivre's theorem
- b) Rotation of a complex variable
- c) Roots of unity, real numbers: multi-valued functions
- d) Trigonometric, hyperbolic, exponential and logarithmic functions
- e) Inverse trigonometric and hyperbolic functions
- f) Functions of a complex variable: Cauchy Riemann equations
- g) Analyticity and non-analyticity
- h) Smooth contours and simply connected curves and regions
- i) Cauchy's theorem
- j) Contour integration
- k) Cauchy's integral formula
- l) Principle values for real and complex integrals
- m) Derivatives of analytic functions
- n) Taylor and Laurent series expansions: regions of convergence
- o) Classification of singularities
- p) Residue theory: formulae for determining residues
- q) Evaluation of integrals of trigonometric functions
- r) Inverse Laplace transform integral; closure to the left or right
- s) Multi-valued functions: branch points, branch cuts
- t) Difficult and easy ways to define a single-value branch of a function
- u) Evaluation of real integrals using branch cuts
- v) Summation of series by complex variable techniques:

3. IDEAL FLUIDS/VORTICITY AND CIRCULATION

- a) Vorticity and Circulation
- b) Vortex lines, streamlines
- c) Helmholtz's theorem (inviscid)
- d) Kelvin's theorem
- e) Bjerkness' theorem
- f) Line vortex

4. TWO DIMENSIONAL POTENTIAL FLOW THEORY

- a) Streamfunction formulation
- b) Vorticity, velocity potentials
- c) Complex potential
- d) Circle theorem
- e) Blasius' theorem for forces and moments over 2-D bodies
- f) Method of images
- g) Free vs. bound singularities

5. ANALYTIC MAPPINGS (TRANSFORMATIONS)

- a) Conformal nature
- b) Critical points
- c) Schwarz-Christoffel transformations
- d) Joukowski transformation and the Kutta condition

6. THREE DIMENSIONAL POTENTIAL FLOW THEORY

- a) Governing Equations of Motion (Euler, Continuity)
- b) Bernoulli's Equation (Compressible and Incompressible)
- c) Laplace's Equation
- d) Boundary conditions for ideal fluid flow
- e) Separation of variables for Laplace's equation in spherical coordinates
- f) Legendre's equation
- g) Stokes' streamfunction
- h) D'Alembert's Paradox
- I) Butler's Sphere Theorem
- j) Rankine Ovoid
- h) Source and sinks general properties
- k) Axisymmetric closed bodies
- l) Biot-Savart law
- m) Forces and moments due to singularities
- n) Weiss' Sphere theorem

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BIBLIOGRAPHY

Applied Mathematics:

“Advanced Engineering Mathematics”, Kreyszig, E., Wiley, 1983

“Operational Mathematics “, Churchill, R.V. , 3rd Ed., McGraw-Hill, 1990

“Methods of Theoretical Physics: Part I: Chapters 1 to 8, Vol. 1”

“Methods of Theoretical Physics: Part II: Chapters 9 to 13, Vol. 2”

P.M. Morse and H. Feshbach, 1st ed., McGraw-Hill, 1953

Vector Analysis:

“Div Grad Curl and All That - An Informal Text on Vector Calculus”, Schey, H.M., Norton, 1992

“Vector and Tensor Analysis with Applications”, A.I. Borisenko and I.E. Tarapov, Dover Publications, Inc. , Translated in 1992

“Methods of Applied Mathematics “, Hildebrand, F.B., 2nd Ed., Publisher: Dover Publications, Inc., 1992

“Vectors, Tensors and the Basic Equations of Fluid Mechanics”, R. Aris, Dover Reissue, 1962

Complex Variables:

“Complex Variables and the Laplace Transform for Engineers”, W.R. LePage, Dover Publications, Inc., 1992.

“Complex Variables and Applications “, J. W. Brown and R. V. Churchill, 6th Ed. McGraw-Hill Companies, 1996.

Math Tables:

“Table of Integrals Series and Products - Corrected and Enlarged Edition”, I.S. Gradshteyn and I.M. Ryzhik, Academic Press, 1980

“Handbook of Mathematical Functions” M. Abramowitz and I.A. Stegun, Dover Publications, Inc., 1970.

Fluid Mechanics:

“An Introduction to Fluid Dynamics”, G.K. Batchelor, Cambridge, 1967

“Fluid Mechanics”, L.D. Landau and E.M. Lifshitz, 2nd Ed., Pergamon Press, 1987

“Vortex Dynamics”, P.G. Saffman, Cambridge, 1992

“Fundamentals of Hydro and Aeromechanics”, Prandtl and Tietjens, Dover Reissue, 1934.

“Applied Hydro and Aeromechanics”, Prandtl and Tietjens, Dover Reissue, 1934.

“Theoretical Aerodynamics”, L.M. Milne-Thomson, 4th Ed., Dover Reissue, 1958

“Elementary Fluid Dynamics”, D.J. Acheson, Oxford, 1990.

“Fundamental Mechanics of Fluids”, I.G. Currie, 2nd Ed., McGraw-Hill, 1993

“Hydrodynamics”, Sir H. Lamb, 6th Ed., Dover Reissue, 1932