ENG ME 542 Advanced Fluid Mechanics

Instructor:

M. S. Howe
EMA 218
mshowe@bu.edu

This course is intended to consolidate your knowledge of fluid mechanics and to develop a critical and mature approach to the subject. It will supply the background preparation for more specialized courses on fluid mechanics, acoustics and aeroacoustics.

Outline syllabus:

Equations of motion. Selected topics in two and three dimensional incompressible fluid mechanics, as discussed in Chapters 1 - 4 of *Hydrodynamics and Sound* (M. S. Howe 2007, Cambridge University Press).

Prerequisites:

Introductory knowledge of Fluid Mechanics; Mathematics to the level of ME 400 (Engineering Mathematics).

Textbooks:

Students of Fluid Mechanics should aim to build a library of classic texts. These are usually considered to be 'too difficult' for the average graduate, and most textbooks in use in American universities are simplified versions of these texts that present interpretations and often misguided simplifications of the originals. Many valuable classics are now out of print, but are often available in libraries and second hand (http://www.abebooks.com/ is a good source), or have been republished by Dover.

Recommended classics:

Batchelor, G. K. 1967 *An Introduction to Fluid Dynamics,* Cambridge University Press.

Birkhoff, G. 1955 *Hydrodynamics – a study in logic, fact and similitude.* Dover publications (republication of edition published by Princeton University Press, 1950)

Birkhoff, G. and Zarantonello 1957 *Jets, wakes and cavities.* New York, Academic Press.

Durand, W. F. 1934. (editor) *Aerodynamic Theory*, 6 volumes. See especially volumes II and III. Second hand only.

Gurevich, M. I. 1965 *Theory of jets in ideal fluids.* New York, Academic Press.

Goldstein, S. 1960 *Lectures on fluid mechanics.* Interscience: New York. (out of print)

Lamb, Horace 1932 *Hydrodynamics* (6th. ed.). Cambridge University Press. (Also available from Dover; paperback version reprinted as a *Cambridge Classic* by Cambridge University Press, 1993). All serious students should have this.

Landau, L. D. and E. M. Lifshitz 1987 *Fluid Mechanics* (Second edition). Oxford: Pergamon.

Lighthill, James 1978 *Waves in Fluids.* Cambridge University Press.

Lighthill, J. 1986 *An Informal Introduction to Theoretical Fluid Mechanics.* Oxford: Clarendon.

Milne-Thomson, L. M. 1968 *Theoretical Hydrodynamics* (5th. edition). London: Macmillan. (Also available from Dover)

Prandtl, L. 1952 *Essentials of Fluid Dynamics.* London, Blackie and Sons. (out of print)

Sedov, L. I. 1965 *Two dimensional problems in hydrodynamics and aerodynamics.* New York: John Wiley.

Stoker, J. J. 1957 *Water Waves.* New York: Interscience Publishers.

For a review of elementary fluid mechanics:

Acheson, D. J. 1990 *Elementary Fluid Dynamics.* Oxford: Clarendon Press.

Books related to acoustics:

Rayleigh, Lord 1945 *Theory of Sound*, Volumes 1 and 2. New York: Dover.

Howe, M. S. *Theory of Vortex Sound*, Cambridge University Press, 2003.

Howe, M. S. *Acoustics of Fluid-Structure Interactions*, Cambridge University Press, 1998

Noble, B. 1958 *Methods based on the Wiener-Hopf Technique.* London: Pergamon Press.

Pierce, A. D. 1989 *Acoustics, An introduction to its principles and applications.* American Institute of Physics.

Course Assessment:

(i) **Paper (50%)**

A paper on a subject to be agreed with the instructor (of between 10 - 20 pages of double spaced type script) is to be submitted at the end of the semester. The paper should consist of either

- a general discussion or survey of a topic based on material drawn from one or more 'classic' texts or other suitable sources

OR

- an account of an analytical or numerical investigation undertaken by the student (with the instructor's guidance) of an approved fluid mechanical model problem

(ii) **Final Examination (50%)**

Rough course syllabus:

Text: *Hydrodynamics and Sound*, Howe 2007, CUP.

Topic	Approximate number of lectures
1. EQUATIONS OF MOTION	2
2. POTENTIAL FLOW	
Sections 1 - 5	1
Sections 6 - 8	1
Section 11	1
Section 12	1
Section 13	1
Sections 15 - 16	1
3. IDEAL FLOW IN TWO DIMENSIONS	
Section 1	1
Section 2	1
Section 3	1
Section 4	1
Section 5	1
Section 6	1
Section 7	2
Section 8	1
Section 12	1
4. ROTATIONAL INCOMPRESSIBLE FLOW	
Section 1	1
Section 2	1
Section 4	1
Section 5	2
Section 7	1

Sample topics for papers

- Role of Green's formula in Fluid Mechanics.
- The incompressible far field.
- Force on a rigid body in incompressible flow.
- The Kirchhoff vector and applications.
- The Kutta-Joukowski condition.
- Leading edge suction.
- The Schwarz-Christoffel transformation.
- Free streamline theory.
- Separation.
- Sedov's method.
- Unsteady thin airfoil theory.
- Creeping flow.
- Boundary layer theory.
- The Kirchhoff vector force formula.
- Vortex-Surface interactions.