ME5460 Fundamentals in Acoustic Radiation and Noise Control  
(section number 16429)  
Course Syllabus, Fall 2004  
Course materials including HW assignments and solutions can be found at:  
http://www.eng.wayne.edu/coe/main.cfm?location=593&facultyID=174

General Information:

Instructor: Dr. Sean F. Wu, Room 2133 Engineering Building
Telephone: 577-3884; E-mail: sean_wu@wayne.edu
3:30 pm to 5:20 pm, Monday & Wednesday in Room 0215 Manoogian
Office Hours: 2:00 pm to 3:00 pm, Monday & Wednesday in Room 2133 Eng. Bldg.
(Other times by appointments)

Text Book: Fundamentals in Acoustics and NVH by S. F. Wu (Course Pack)
Reference Book: Acoustics: An Introduction to Its Physical Principles and Applications
by A. D. Pierce (required), Acoustical Society of America, 1994

Prerequisites: Senior or graduate standing

Overall Course Goals: Students who successfully complete ME5446 will be able to:

• understand the nature and origin of sound generation, propagation, and interaction with
  surrounding fluid medium and solid surfaces, and calculate sound pressure and power
  levels from multiple sources in different environments;
• understand the mechanisms of sound reflection, absorption, and transmission through
  multi-layer panels;
• understand the properties of sounds in large and small enclosures and resonance.

Specific Learning Objectives: Letters in brackets refer to the BSME Program Objectives A – J.
Numbers in brackets refer to the methods of evaluation, with 1 = Homework; 2 = Quizzes and
Exams; 3 = Projects and Competitions; 4 = Presentations; and 5 = Laboratory Reports;)

Students who successfully complete ME 5460 will be able to:

• understand the nature and origin of sound generation and propagation and be able to
derive the wave equation from the conservation of mass, conservation of momentum, and
pressure-density relation [A, C, G; 2, 3];
• calculate speed of sound, acoustic energy, intensity, and power and estimate sound
  pressure levels of multiple sources or the net contribution of a source in a noisy
  environment [A, C, G; 2, 3];
• understand mechanisms of acoustic wave interaction with solid surfaces and be able to
calculate acoustic reflection and transmission coefficients [A, C, D, G; 2, 3];
• understand mechanisms of monopole, dipole, and quadrupole sources and use of the
  free-space Green’s function to predict sound radiation from simple point sources [A, C,
  D, G, H; 2, 3];
• understand diffuse theory and be able to calculate reverberation time, room constant, and
  absorption coefficient of different materials [A, B, C, D, G, H; 2, 3];
• understand mechanisms of Helmholtz resonators, mufflers, and acoustic filters to control
  unwanted sounds [A, B, C, D, G, H; 2, 3].
Relationship of Course to Program Educational Objectives:

Strongly contributes to the BSME Program Educational Objectives that successful students will:
- be able to understand scientific principles and apply them to the practice of engineering [A];
- possess the problem-solving skills, background, and confidence necessary to educate themselves continually throughout their careers [C];
- be able to apply computers as tools for engineering [D];
- be able to develop creative solutions to engineering problems [G].

Contributes to the BSME Program Educational Objectives that successful students will:
- be able to communicate effectively [B];
- be able to work well as part of a team [H].

BSME Program Educational Objectives (as revised on October 30, 1998): The main objective of our undergraduate program is to provide an outstanding curriculum and learning environment, so that, following completion of our undergraduate program, BSME graduates will:

A. be able to understand scientific principles and apply them to the practice of engineering;
B. be able to communicate effectively;
C. possess the problem-solving skills, background, and confidence necessary to educate themselves throughout their careers;
D. be able to apply computers as tools for engineering;
E. be able to apply the basic principles of measurement, data analysis, and design of experiments, learned through “hands-on” laboratory experience;
F. be able to practice engineering with ethical standards and a responsibility to society;
G. be able to develop creative solutions to engineering problems;
H. be able to work well as part of a team;
I. be able to apply the design process to engineering problems, including the consideration of different technical alternatives while bearing in mind cost, environmental concerns, safety, and other constraints;
J. be able, based on their first-hand design experience, to analyze, construct, test, and evaluate an engineering design.

Grading Policy: Homework will be assigned, but not graded. Instead, homework materials will be tested in unannounced quizzes. The final grade of this course will be based on quizzes, midterm, and final examinations under the following weighting scale:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes (five)</td>
<td>30% (6% per quiz)</td>
</tr>
<tr>
<td>Projects</td>
<td>20% (10% per project)</td>
</tr>
<tr>
<td>Examinations (two)</td>
<td>60% (30% per exam)</td>
</tr>
</tbody>
</table>

The final grade of this course will be represented by a letter grade according to the following categories:

A: 92 – 110;  A+: 89 – 91;  B+: 86 – 88;  B: 82 – 85;  B+: 79 – 81;  C+: 76 – 78;
C: 72 – 75;  C+: 69 – 71;  D+: 66 – 68;  D: 62 – 65;  D+: 59 – 61;  E: less than 59
Important Remarks: There will be no make up quizzes and examinations. Homework will be assigned, but not collected. Solutions to homework assignments will be posted on Internet. Computer projects must be turned in on due dates. No late submission will be accepted.

Policy on Withdraw: The last day to drop a class with a tuition refund is Monday, September 20, 2002. The College of Engineering does not allow withdraw from courses after the 5th week of classes except under exceptional circumstances. Failing of a class is not an acceptable excuse for withdrawal after the 5th week.

Policy on Deferred Grades: A grade of ‘I’ should be assigned (which MUST be made up within one year of assignment of the grade) only if: (1) the student is not currently failing the class; (2) there is not a substantial quantity of work yet to be completed; (3) there is no extra work required of the instructor beyond the normal duties of grading the paper/exam; and (4) there is no need for the student to attend the class in subsequent terms. A grade of ‘X’ should be assigned if there is no basis on which to provide a grade for the student (i.e., the student never showed up in the class).

Student Conduct: It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Thus, a student should not falsely claim the work of another as one's own, or misrepresent him/herself so that the measures of one's academic performance do not reflect his/her own work or personal knowledge. In this regard, cheating will not be tolerated. Cheating includes (but is not limited to) any communication (written or oral) during quizzes and examinations and sharing of work, such as using the same models or computer programs or copying work. All assignments and laboratory reports must be an individual effort unless specifically noted. STUDENTS WHO CHEAT ON ANY ASSIGNMENT OR DURING ANY EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE. Therefore avoid all appearance of improper behavior! Students who witness cheating should report the incident to the instructor as soon as possible. Students are also welcome to discuss any concerns related to cheating with Dr. Ronald F. Gibson, Interim Chairman of Mechanical Engineering Department.
# Week-by-week outline of materials/activities to be covered

<table>
<thead>
<tr>
<th>Date</th>
<th>Materials/Activities</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/08</td>
<td>Demonstrations of sound sources and waves; Sound sources and propagation of sound waves</td>
<td>215 Mano</td>
</tr>
<tr>
<td>09/13 &amp; 09/15</td>
<td>Conservation of mass; Euler’s equation; Pressure-density relations; Wave equation; Plane traveling waves; Waves of constant frequency</td>
<td>215 Mano</td>
</tr>
<tr>
<td>09/20 &amp; 09/22</td>
<td>Demonstration of direct measurement of the sound speeds; Adiabatic versus isothermal sound speed; Acoustic energy, intensity, and power</td>
<td>215 Mano</td>
</tr>
<tr>
<td>09/27 &amp; 09/29</td>
<td>Problem solving sessions</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td><strong>Quiz 1: Wave equation to Plane waves on 09/29</strong></td>
<td></td>
</tr>
<tr>
<td>10/04 &amp; 10/06</td>
<td>Spherical waves; Frequency content of sounds; Proportional frequency bands; Levels and decibels; Frequency weighting; Combining levels</td>
<td>215 Mano</td>
</tr>
<tr>
<td>10/11 &amp; 10/13</td>
<td>Problem solving sessions</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td><strong>Quiz 2: Octave bands and combining SPL values on 10/09</strong></td>
<td></td>
</tr>
<tr>
<td>10/18 &amp; 10/20</td>
<td>Boundary conditions on impermeable surfaces; Specific acoustic impedance; Radiation of sound by a vibrating piston within a tube</td>
<td>215 Mano</td>
</tr>
<tr>
<td>10/25 &amp; 10/27</td>
<td>Reflection and transmission at an interface between two fluids; Multi-layer transmission and reflection; <strong>Quiz 3: Sound transmission on 10/27</strong></td>
<td>215 Mano</td>
</tr>
<tr>
<td>11/01 &amp; 11/03</td>
<td>Problem solving sessions</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td><strong>Examination 1 (wave equation to sound transmission) on 11/03</strong></td>
<td></td>
</tr>
<tr>
<td>11/08 &amp; 11/10</td>
<td>Radially and transversely oscillating sphere; Multipoles; Free-space Green’s function;</td>
<td>215 Mano</td>
</tr>
<tr>
<td>11/15 &amp; 11/17</td>
<td>The Helmholtz integral theory and its applications;</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td><strong>Quiz 4: Monopoles, dipoles, and quadrupoles, etc. on 11/17</strong></td>
<td></td>
</tr>
<tr>
<td>11/22 &amp; 11/24</td>
<td>Sabine-Franklin-Jaeger theory and its applications</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td><strong>No class on November 24, which is scheduled as Friday</strong></td>
<td></td>
</tr>
<tr>
<td>11/29 &amp; 12/01</td>
<td>Helmholtz resonators; Mufflers; Acoustic Filters</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td>Problem solving sessions</td>
<td></td>
</tr>
<tr>
<td>12/06 &amp; 12/08</td>
<td><strong>Quiz 5: Sabine Theory and its applications on 12/06</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>General Review</strong></td>
<td></td>
</tr>
<tr>
<td>12/13 &amp; 12/15</td>
<td>Problem solving sessions</td>
<td>215 Mano</td>
</tr>
<tr>
<td></td>
<td><strong>Presentation of Projects 1 and 2</strong></td>
<td></td>
</tr>
<tr>
<td>12/20</td>
<td>Examination 2 (multipoles to Helmholtz resonators and mufflers)</td>
<td>215 Mano</td>
</tr>
</tbody>
</table>

**Due Dates for Computer Projects**

- **Project 1:** Design of a Reverberation Chamber  
  Due Date: November 10, 2004
- **Project 2:** Design of a Helmholtz Resonator  
  Due Date: December 20, 2004