AME

Audio and Music Engineering Curriculum Guide
The Hajim School of Engineering and Applied Sciences
University of Rochester
Fall/Spring 2017/2018
The Audio and Music Engineering (AME) major combines studies in engineering and applied sciences with music and audio production to give students a technically rigorous, design-based education in the field of audio, music and sonic engineering. The curriculum is built on a foundation of basic math and science and integrates elements of music, audio content production, acoustics, fundamental engineering science, signal processing hardware and software, electronics, and software engineering. Through a series of design and project courses integrated with their other course work, students build a project portfolio throughout their studies capped by a senior design project. The Bachelor of Science in AME (BS AME) is offered. Students also may earn a Bachelor of Arts in Engineering Science (BA-ES) with a program focus in AME. It also is possible to complete a minor in AME.
The Department of Electrical and Computer Engineering coordinates the program in Audio and Music Engineering. Currently the Bachelor of Science and a Minor in AME are offered. A Bachelor of Arts major in AME is not offered, however it is possible to complete a Bachelor of Arts in Engineering Science with a program focus on Audio and Music Engineering. The MSEE and Ph.D. degrees with a concentration and research in Acoustics, Audio and Music Signal Processing are available through the ECE Department as well. AME students may choose to earn a Master of Science degree in Electrical Engineering with as little as one additional year of study following completion of the AME BS program. Participation in the GEAR (Graduate Engineering at Rochester) program is open to all incoming freshman. If accepted into this program, an undergraduate is assured admission to the EE masters program provided an undergraduate GPA of 3.2 is achieved in their undergraduate studies.

The Audio and Music Engineering (AME) program provides students a multi-disciplinary education combining studies in engineering and applied science with music and audio arts. It serves a wide range of students, from those wishing to gain a technically rigorous, design-based engineering education in the field of audio engineering to students of music and the humanities wishing to increase their knowledge and skills in the technology of music and audio media creation to complement their other studies. Experiential hands-on learning, design, and the creative process are the foundation of the program. The central pillar of each student’s education is their design/creative project portfolio built over the course of their studies to illustrate their engineering skills and creative abilities. The field of audio and music engineering extends far beyond the traditional music recording industry. Career paths for program graduates span hundreds of companies representing industries such as: computer hardware and software manufacturing, audio software development, music and audio recording and production, core audio and signal processing technologies and component manufacturing, musical instruments and audio equipment manufacturing, video gaming, automotive, architectural acoustics, urban planning, industrial noise monitoring and control, consumer product design, and research and development in acoustics.

Our students also have the opportunity to participate in research, working closely with faculty members in department research programs during the academic year and in summer internships.

As described elsewhere in this guide, the AME BS degree requires each student to complete one Cluster, specifically in Music. Students following the Bachelor of Arts in Engineering Science program are required to complete two clusters, one of which may be in music. It also is possible to earn a minor in Music in combination with the BS and BA programs and the BA in Engineering Science program has enough free elective space to enable students to earn a dual major in Music or another area. Students planning to double major should consult their advisor early in their studies to plan their program. Multiple student advising resources are available including: the primary faculty advisor assigned to each AME student in their Freshman year, the AME Program Undergraduate Coordinator (Barbara Dick), the AME Program Chair (Mark Bocko), and the Hajim School Dean’s office advising staff (Lisa Norwood). Students requiring assistance should first consult their primary faculty advisor or the AME Program Undergraduate Coordinator. Faculty advisors are available to help students plan their programs of study, declare a major or minor, drop and add courses, transfer credits from another institution, register for independent study credits, explore study abroad options, arrange internships and fellowships, and to petition for cluster exceptions. The AME Program Chair must review and approve all transfer courses.
PROGRAM OBJECTIVES

1. Students will acquire knowledge and skill in the mathematics underlying audio and music engineering analysis and design, including calculus, linear algebra, and discrete mathematics.

2. Students will demonstrate basic competency in Music including the ability to read music, knowledge of keys and transposition, basic keyboard skills, and a grasp of the basics of harmony.

3. Students will develop a firm foundation in the physical sciences underlying audio and music engineering analysis and design, including fundamental physics and acoustics.

4. Students will be able to use the tools of audio and music engineering, including computer simulation, design and analysis software, and laboratory measurement equipment.

5. Students will be able to design and conduct experiments, and analyze and correctly interpret data.

6. Students will gain a sufficient foundation in the fundamental areas of audio and music engineering to understand problems in a broad context. These fundamental areas include: basic music theory, acoustics, audio perception and cognition, electronics, digital and computer systems, digital signal processing, and computer software.

7. Students will have the in-depth training in five areas of AME to conduct detailed analysis, design and project planning and will develop the skills to bring production and design projects to successful completion.

8. Students will gain the skills and general knowledge necessary to function effectively in engineering and project teams.

9. Students will be exposed to the issues of professionalism and ethical responsibility and understand the legal and ethical issues of intellectual property, copyright, and piracy.

10. Students will be able to communicate effectively with their peers and the public in written, oral, and graphical forms.

11. Students will develop an appreciation of the societal context and impact of engineering.

12. Students will learn to appreciate the value of the creation and dissemination of new engineering knowledge and the need to engage in life-long learning.

13. Students will broaden their education through exposure to the humanities and social sciences.
Students wishing to declare a major in AME must file a completed "AME Curriculum Planning Form" (See Appendix 1), along with the Concentration Approval Form. This usually is completed during the fourth semester of study. The minimum requirements for admission to the AME BS program are completion of the following:

1. AME 140, AME 191, ECE 210, and ECE 114 with a minimum cumulative GPA of 2.3.
2. MTH161, 162, 164, and 165 or equivalent math sequence
3. PHY121, 122
4. University primary writing requirement, usually satisfied by taking WRT 105.
5. Students may not be admitted to the major if they are on Academic Probation in the College

Under special circumstances, such as transfer from another institution or change of intended major, students may not have completed all the requirements for BS AME program admission by the end of the sophomore year. Such students may qualify for conditional admission by submitting a petition form available from the AME Undergraduate Coordinator. The petition for conditional admission and an up-to-date AME Curriculum Planning form should be submitted to the AME Undergraduate Program Chair. The application must present a realistic plan, approved by the student's advisor, for completion of all AME program admission requirements within one year. Failure to meet the requirements within one year will result in removal from the major.

Only the Administrative Committee of the Hajim School of Engineering and Applied Sciences can make exceptions from the general degree requirements published in the Official Bulletin of the University. Petition forms for Administrative Committee consideration may be obtained from the AME Program Coordinator.

**IMPORTANT DATES**

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 30, 17</td>
<td>Classes begin</td>
</tr>
<tr>
<td>Sept. 20</td>
<td>Last day to add 4 cr. Indep. Study course</td>
</tr>
<tr>
<td>Sept. 27</td>
<td>Last day to drop/add</td>
</tr>
<tr>
<td>Oct. 9-10</td>
<td>Fall Break</td>
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<tr>
<td>Nov. 6-10</td>
<td>Spring registration</td>
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<tr>
<td>Nov. 15</td>
<td>Last day to S/F or withdraw from a class</td>
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<tr>
<td>Nov. 22-26</td>
<td>Thanksgiving break starts</td>
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<tr>
<td>Dec. 13</td>
<td>Last day of classes</td>
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<tr>
<td>Dec. 14-16</td>
<td>Reading Period</td>
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<tr>
<td>Dec. 17-22</td>
<td>Final exams</td>
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<tr>
<td>Dec. 22</td>
<td>Winter Recess</td>
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<tr>
<td>Jan. 17, 18</td>
<td>Spring semester begins</td>
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<tr>
<td>Feb. 7</td>
<td>Last day to add 4 cr. Indep. Study course</td>
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<tr>
<td>Feb. 14</td>
<td>Last day to drop/add</td>
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<tr>
<td>Mar. 10-18</td>
<td>Spring Break</td>
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<tr>
<td>April 2-6</td>
<td>Fall registration</td>
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<tr>
<td>April 4</td>
<td>Last day to S/F or withdraw from a class</td>
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<tr>
<td>May 1</td>
<td>Last day of classes</td>
</tr>
<tr>
<td>May 2-5</td>
<td>Reading period</td>
</tr>
<tr>
<td>May 6-13</td>
<td>Final exams</td>
</tr>
<tr>
<td>May 20</td>
<td>Commencement</td>
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The BS AME program is built on a foundation of basic math, science, programming and music and includes advanced course work in fundamental engineering science, audio content production, audio hardware and audio software. The credit hour requirements for the BS AME degree are given in the following table.

<table>
<thead>
<tr>
<th>Core Area</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Mathematics</td>
<td>16</td>
</tr>
<tr>
<td>Science</td>
<td>16</td>
</tr>
<tr>
<td>Engineering</td>
<td>62</td>
</tr>
<tr>
<td>Writing (WRT105, 273)</td>
<td>6</td>
</tr>
<tr>
<td>Hum &amp; Soc Sci</td>
<td>20</td>
</tr>
<tr>
<td>Free electives</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>132</strong></td>
</tr>
</tbody>
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**Core Requirements**

**Mathematics** (Complete one calculus sequence)
MTH161,162,164,165 or MTH171,172, 173, 174
MTH141,142,143 may be substituted for MTH161,162

**Physics** (2 courses)
PHY121, PHY122; or PHY141, PHY142

**Other Science and Mathematics** (2 courses)
AME233/PHY283 is required for the BS AME major. The remaining course may be in astronomy, biology, brain and cognitive sciences, chemistry, earth and environmental sciences, mathematics, physics, or statistics.

**Basic Music Competency** All AME students must take a minimum of 10 credits of music courses, either from the River Campus Music Department or at the Eastman School of Music. This includes 8 credits of music theory and 2 credits of musicianship. The minimum requirement is completion of MUR101 and MUR111, however students with appropriate background and demonstrated proficiency in music theory may begin in a higher level course such as MUR110 followed by MUR111. The appropriate starting course is determined by placement exam administered by the River Campus Music Department, or for Eastman students placement in Music Theory is determined by the ESM faculty. To meet the musicianship requirement, students normally would complete two one-credit courses MUR109 and MUR113. Courses taken to fulfill the AME music requirement also may be counted toward a Music Cluster to meet the general AME Humanities or Social Science cluster requirement.

The BS AME major requires completion of courses and Portfolio projects in 5 subject areas: Recording Arts and Sound Design, Acoustics, Audio Electronics, Signal Processing and Software Design. The required and elective courses for the BS AME degree are listed below. All courses are 4 credits unless indicated otherwise. **Optional elective courses are shown in red.**
Recording Arts and Sound Design – The focus is on audio and music recording and production, audio content creation and sound design:
- AME140 – Intro to Audio and Music Engineering
- AME191 – Art and Technology of Recording
- AME192 – Critical Listening for Audio Prod
- AME193 – Sound Design
- AME 194 – Audio for Visual Media
- AME240 – Revolutions in Sound: Artistic and Technical Evolution of Sound Recording
- AME391 – Applied Recording Arts
- AME393 – Applied Sound Design

Acoustics – Studies in acoustics range from fundamental acoustics, architectural acoustics, acoustic design, the acoustics of musical instruments, hearing and auditory perception:
- AME233 (PHY283) – Musical Acoustics
- AME292 – Acoustics Portfolio (2)
- ECE 432 – Acoustics

Audio Electronics – Analog and digital electronics for audio - from vacuum tubes to custom integrated circuits:
- ECE210 – Circuits and Microprocessors for Scientists and Engineers
- ECE221 – Electronic Devices and Circuits
- AME223 – Audio Electronics
- AME295 – Audio Electronics Portfolio (2)
- ECE216 – Microprocessors and Data Conversion
- ECE222 – Integrated Circuits: Design and Analysis
- ECE261/461 – Introduction to VLSI

Signal Processing – Digital signal processing is the core of digital audio. The following courses are offered:
- ECE241 – Signals
- AME272 – Audio Digital Signal Processing
- AME294 – Audio DSP Portfolio (2)
- AME277 Computer Audition
- ECE246/446 – Digital Signal Processing

Software Design – The principles and practice of programming and software development for audio:
- ECE114 – Intro to C/C++ Programming
- AME262 – Audio Software Design I
- AME264 – Audio Software Design II
- AME196 Interactive Music Programming
- CSC172 – The Science of Data Structures
- CSC210 – Web Programming

Senior Design – All AME BS students must complete a one-year senior design project
- AME386/387 – Senior Design Project I & II
Humanities/Social Science Requirement – BS AME majors must take at least 20 credits in the humanities and social sciences (H&SS), including at least one course in the humanities and at least one course in a social science. This requirement includes one 3-course Cluster. Often, AME students will take a Cluster in Music, although this is not required. Courses in business may not be used to satisfy this requirement. Students also are encouraged to take some H&SS courses beyond the introductory level. Language courses at the 101 level are accepted only when followed by another, more advanced course in the same language. Students should consult their advisors with any questions.

Notes – Students can not take BOTH MUR 101 and MUR 110 for the requirement.

Business courses from the Simon School may not be used to satisfy the H/SS distribution requirement. Also, no computer courses offered in the humanities or social sciences may be used as a H&SS distribution course.

Ordinarily, courses taken at the University of Rochester to meet the requirements in H&SS are 4 credit hour courses. Consult your advisor concerning 2 or 3 credit courses (including transfer courses). You may need to petition the Undergraduate Committee to use such courses for the H&SS distribution requirement.

The following restriction applies to all courses used to satisfy the distribution requirement: Two 2-credit courses may be combined to fulfill one 4-credit distribution requirement only if both courses are from the same discipline. No more than two courses may be combined to count toward a distribution requirement. However any number of two, 2-credit courses from different disciplines may be substituted for other 4-credit free electives.

Upper Level Writing – The University’s Upper-level Writing Requirement applies to all majors. Within the BS Audio and Music Engineering major the requirement is met through work in AME192, AME193, AME233, AME262 and AME386. Students who transfer credit for any one or more of these courses from another institution to the UR must consult with the AME Program Coordinator to determine if their program satisfies the writing requirement. WRT 273 – Professional writing is also required of all AME majors.
BS AME CURRICULUM AND SAMPLE COURSE SCHEDULE

To meet graduation requirements, BS-AME majors must achieve a minimum cumulative grade-point average of 2.0 in the required AME courses. In addition, 132 total credits are required for graduation with an overall cumulative grade point average of 2.0. By placement exam of RC Music Department - students may need to substitute MUR101 or MUR110 for MUR111.
BACHELOR OF ARTS IN ENGINEERING SCIENCE AME OPTION

Students interested in studying Audio and Music Engineering, but who do not wish to pursue the BS AME degree, may design a specialized program of study within the Hajim School’s Bachelor of Arts in Engineering Science (BA-ES) major. The BA-ES program enables flexibility to allow students to complete a double major in topics such as music or business.

The Bachelor of Arts degree in Engineering Science is a multidisciplinary program that emphasizes understanding and application of engineering, scientific and mathematical principles. The program provides a broad foundation in the sciences and mathematics that underlie engineering, and provides students the opportunity to obtain an in-depth knowledge in an area of their choosing through technical electives. This program offers considerable flexibility and permits students to develop an individualized plan of study.

In addition to taking core courses in mathematics, physics, and other basic sciences, students study core engineering science topics in areas of their choosing. Focus areas of study include, but aren’t limited to, biomedical, chemical, electrical and computer, mechanical, and audio and music engineering as well as optics, and computer science. Engineering Science students achieve both depth and breadth in engineering and science, and are able to function across disciplines, and graduate well prepared for advanced studies, as well as professional employment. Possible career paths include patent law, technical writing, science/technology assessment, technical sales and marketing, and science and engineering education.

Because no standardized curriculum exists, the BA in Engineering Science major is not ABET-accredited. Engineering Science students who intend to seek licensure as a Professional Engineer should be aware that this non-accredited degree program will require additional education and/or work experience to qualify to take the Fundamentals of Engineering examination.

Please consult with the AME Program Coordinator to receive a copy of the BA-ES degree requirements and to set up a meeting with an AME advisor to design a specialized program of study.
OTHER PROGRAM REQUIREMENTS

TRANSFER CREDITS

If a student wishes to take a course at another institution to satisfy an AME degree requirement, prior approval is required and proper supporting documentation about the course must be submitted to the AME Program Coordinator. A “Course Approval Form,” available in the ECE Office is to be used for this purpose. Students are strongly advised to seek the advice of their advisor before registering for a course at another institution. Completed forms will be forwarded to the Undergraduate Program Chair for action.

INTERNSHIPS AND PRACTICUM

AME majors are strongly encouraged to participate in industry internships. Only in rare cases can internship experiences be used for academic credit. Students who wish to obtain credit for an internship must obtain prior approval from the AME Program Chair.

The Engineering Practicum program, supervised jointly by the Hajim School of Engineering and Applied Sciences and the Gwen M. Greene Career and Internship Center, is a way to gain valuable work experience. A student in this program takes one semester and the summer preceding or following to work at a company. Academic credit is not granted, but the work experience and references obtained are valuable in later job searching. Typically graduation is delayed by one semester but students with Advanced Placement credit or summer classes may still graduate within 4 years. Additional information, including example programs, is available from the Hajim School of Engineering and Applied Sciences office in Lattimore Hall, or from the Gwen M. Greene Career and Internship Center.

FIVE-YEAR BS/MS PROGRAM

AME juniors contemplating graduate work may consider the special five-year program offered by the ECE Department in which students earn a BS AME degree plus a Masters Degree in Electrical Engineering. This program enables a seamless transition between undergraduate and graduate study. Program enrollment is competitive and students must apply for admission before the spring of their senior years. Students may take up to 8 credit hours of courses in their Senior year that will count toward their MS degree. Through a special program initiated by the Hajim School of Engineering and Applied Science, students who have been formally accepted into the program will be granted a partial tuition scholarship for the fifth year of study (only after the BS degree has been awarded).

Students should consult the UR Graduate Studies Official Bulletin for the MS degree requirements and they should meet with a faculty member to develop an integrated BSAME/MSEE program of study.

(https://www.rochester.edu/GradBulletin/)
The AME Minor consists of 18-20 credit hours of study in AME or closely related fields. Note that the AME Minor Tracks specified below that require only 18 credit hours each include a design/portfolio component. The other AME Minor Tracks require 20 credit hours of regular courses.

Students must choose one of the following AME Minor Tracks and corresponding course sequences:

**Recording and Sound Design (20 Credits Total)**
- AME 191: The Art and Technology of Recording
- AME 192: Critical Listening for Audio Production
- AME 193: Sound Design
- One additional track course

**Audio Signal Processing (18 Credits Total)**
- ECE 241: Signals
- AME 272: Audio Signal Processing
- AME 294: Audio DSP Portfolio (2 credits)
- One additional track course

**Audio Electronics (18 Credits Total)**
- ECE 210: Circuits and Microprocessors for Scientists and Engineers
- ECE 221: Electronic Devices and Circuits
- AME 223: Audio Electronics
- AME 295: Audio Electronics Portfolio (2 credits)

**Audio Computing and Software Design (20 Credits Total)**
- ECE 114: Introduction to Computers and Programming (or CSC 171)
- AME 262: Audio Software Design
- AME 263: Computational Models of Music or AME 264: Audio Software Design II
- One additional track course

**Musical Acoustics (18 Credits Total)**
- AME 191: The Art and Technology of Recording
- AME 233: Musical Acoustics
- AME 292: Acoustics Portfolio (2 credits)
- One additional track course

Acceptable MUR Classes: MUR 101, MUR 110, MUR 111, MUR 112, MUR 201, MUR 202, MUR 211, MUR 212, MUR 241, MUR 234, or equivalent courses offered at the Eastman School of Music.

If a student wishes to make course substitutions in any of the above tracks they should contact the AME Program Coordinator to seek approval prior to taking any alternative classes.
AME 140/ECE 140/EAS 103 Introduction to Audio and Music Engineering - The core science and technology of audio. Oscillations, vibration of strings, musical tuning systems, overtones and timbre, modes of oscillation, Fourier analysis, electrical circuits, analog signals. Basic digital signal processing concepts, conversion of sound to digital format, frequency analysis, digital filtering and signal processing and musical sound synthesis. AME140 is recommended as an introduction to the Audio and Music Engineering major but it is accessible to students of music or other non-technical disciplines who wish to learn the fundamentals of music technology and enjoy building projects. Lectures and weekly lab sessions. Prerequisites: High School Algebra and Trigonometry (F)

AME 191 The Art and Technology of Recording - This course covers the acoustical and psychoacoustic fundamentals of audio recording including the nature of sound, sound pressure level, frequency and pitch, hearing and sound perception, reflection, absorption and diffusion of sound, sound diffraction, room acoustics, reverberation, and studio design principles. The course also provides practical experience in audio recording including an introduction to recording studio equipment, microphones and microphone placement techniques, signal flow, amplification, analog and digital recording, analog to digital conversion, digital processing of sound, multi-track recording and an introduction to mixing and mastering. Each student is required to complete a substantive recording project at the end of the course. (F/S)

AME 192 Critical Listening and Audio Production - This course is a continuation of AME191. Emphasis is on the development of critical listening skills and proficiency in audio mixing and mastering. Fundamental topics covered include the human auditory system, theories of hearing and audio perception, perception of loudness and pitch, critical bands and auditory masking, beats and roughness, temporal and pitch acuity, binaural hearing. Listening skills development include hearing “width” and “depth” in audio, mixing techniques in various musical genres, recognition of various effects including reverb, delay, compression, phasing and distortion. Production skills development includes equalization and achieving spectral balance, the use of compression and dynamic range control, achieving depth and dimension in recordings, panning and auditory scene control. Students will complete an extensive mixing and mastering project at the end of the course. Prerequisite: AME 191 (F/S)

AME 193 Sound Design - The course is intended to provide students a basic understanding of sound design & creation, and working with sound for picture. The emphasis is on demonstrations and hands-on experience to enable students to gain a practical knowledge of sound and music production using computers. Fundamental topics include synthesizers & samplers; recording and editing with Pro Tools; sound effect creation' foley and automatic dialog replacement; basic soundtrack composition; and working to picture. Many techniques are explored using software and hardware throughout the course. Students complete a major project at the conclusion of the course. Instructors Permission required (F/S)

AME 194 Audio for Visual Media - This course is intended to provide students with a basic understanding of the process and the skills for creating music for picture. The course emphasizes hands-on experience where students gain practical skills in scoring to picture using computers and it features guest lectures by industry leading professionals, who will share their insights on creating music for TV Shows, Advertising, Movies, Gaming, Animation, and Industrial Work. Topics also include soft synthesizers, samplers and virtual instruments; recording and editing with Pro Tools and Logic; and sound design on audio workstations. Students will complete a number of projects throughout the course. Instructor Permission only (F/S)

AME 196 Interactive Music Programming - In this course, students will explore digital audio synthesis and real-time interactive technologies by studying two audio programming languages, ChucK and Pure Data. They will be able to manipulate sound with MIDI controllers, laptops, mobile devices, joysticks, mice, Kinect sensors, and Wiimotes. Students will have a midterm presentation to demonstrate their programs in ChucK. At the end of the semester, we will have a showcase for interactive performance. This interdisciplinary course does not require any programming experience. All students, including music and technology majors, are welcome to take this course. (F)
AME 197 – Audio for Gaming - The course is intended to provide students a basic understanding of audio for gaming. The emphasis is on demonstrations and hands-on experience to enable students to gain a practical knowledge of the integration of sound and music into video games using middleware. Students will primarily work with Wwise, Unity, Reaper, Pro Tools and Logic Pro X; Topics will include basic soundtrack composition for interactive; Advanced sound effect creation; foley; Dialog recording and editing; Working directly within a game environment; and audio for virtual reality. Supplementary software discussed will include FMod, Unreal, Fabric, Nuendo, and Elias. The course will also feature guest lectures by industry leading professionals, who will share their experience and insights. (F)

AME 223 Audio Electronics - The devices, circuits and techniques of audio electronics are covered in this course. Included is a survey of small signal amplifier designs and small-signal analysis and characterization, operational amplifiers and audio applications of opamps, large-signal design and analysis methods including an overview of linear and switching power amplifiers and power supply design. The course also covers the design of vacuum tube circuits, nonlinearity and distortion. Other important audio devices are also covered including microphones, loudspeakers, analog to digital and digital to analog converters. Low-noise audio equipment design principles including proper grounding and shielding techniques are also covered. Prerequisite: ECE 221 or permission of Instructor (S)

AME 233/ECE 233/PHY 233/TEE 433 Musical Acoustics - Engineering aspects of acoustics. Review of oscillators, vibratory motion, the acoustic wave equation, reflection, transmission and absorption of sound, radiation and diffraction of acoustic waves. Resonators, hearing and speech, architectural and environmental acoustics. (S) Prerequisites: Linear algebra and Differential Equations (MTH 165), Multivariable Calculus (MTH 164), and Physics (PHY 121) or equivalents (S)

AME 240 Revolutions in Sound: Artistic and Technical Evolution in Sound Recording - Sound recording has changed the way we listen to music and the way music is performed for over a century. This course aims to provide a multifaceted account of the history of recording and reproduction, from Edison’s 1877 invention of the phonograph to digital recording, MP3, and audio streaming. In reviewing the major innovations in recording technology, we will focus on the changes in the quality and aesthetics of recorded sound, as well as the evolving roles of engineers, producers, and musicians in commercial recording. In addition, this course will investigate how technology has shaped musical experience, and how different types of music, including classical, jazz, popular, and folk, have in turn influenced the development of recording technology. A special topic will address ethical and copyright issues in the use of recordings, and in the appropriation of music by others. All students, including technology and music majors, are welcome (S)

AME 262/ECE 475 Audio Software Design I - This course aims to give students the ability to develop their own audio/music programs in C and a few major open-source audio programming languages. It begins with an introduction to computer music and audio programming, and a comparative survey of audio programming languages. After an overview of the C language, we then explore the topics of programming for sound synthesis. The second half of this course introduces the primary techniques of sound design using the audio programming environments of Pure Data and Csound. Students will practice their programming techniques through a series of programming assignments and a final project. Prerequisite: ECE 114 or Instructor Permission (F)

AME 264/ECE 476 Audio Software Design II - This course is a sequel to AME262/ECE475 Audio Software Design I. The first half of the course will begin with an overview of the C++ language and then explore designing audio effect plug-ins in C++ and Faust, using audio digital signal processing theory. Students will learn how to design VST and AU plug-ins for Pro Tools, Logic, and other digital audio workstations (DAWs). The second half of the course will focus on audio programming for iOS apps in Objective-C and Swift, which is the new programming language for iOS and OS X. Students will learn how to make musical apps, including a guitar tuner app. A special topic will introduce audio programming for computer and video games. Prerequisites: AME 262 or ECE 475 or Instructor Permission (S)
AME 272/472/ECE 472/TEE 472  Audio Signal Processing For Analysis and Synthesis of Music - This course is a survey of audio digital signal processing fundamentals and applications. Topics include sampling and quantization, analog to digital converters, time and frequency domains, spectral analysis, vocoding, analysis and synthesis of digital filters, audio effects processing, musical sound synthesis, and other advanced topics in audio signal processing. Implementation of algorithms on dedicated DSP platforms is emphasized. Prerequisites: ECE 114 and basic Matlab programming, ECE 241 or other equivalent signals and systems courses (S)

AME 277/477  Computer Audition - Computer audition is the study of how to design a computational system that can analyze and process auditory scenes. Problems in this field include source separation (splitting audio mixtures into individual source tracks), pitch estimation (estimating the pitches played by each instrument), streaming (finding which sounds belong to a single event/source), source localization (finding where the sound comes from) and source identification (labeling a sound source). Prerequisites: ECE 246/446 or ECE 272/472 or other equivalent signal processing courses, and Matlab programming. Knowledge of machine learning techniques such as Markov models, support vector machines is also helpful, but not required (F).

AME 292 Acoustics Portfolio - This is a follow on course to AME233, Musical Acoustics. In this course students will complete a major project in acoustics, such as the acoustical characterization of an architectural space, design or re-design of an architectural or studio space, development of acoustical computer simulation tools, design or characterization of acoustic musical instruments, design and fabrication of loudspeakers, design and implementation of a live sound or sound reinforcement system, or any other project in acoustics with the agreement of the instructor. Weekly meetings and progress reports are required. Prerequisite: AME 223 (F)

AME 294 Audio DSP Portfolio - This is a follow on course to AME272, Audio Digital Signal Processing. Students will complete a major design/build project in the area of audio digital signal processing in this course. Examples include a real-time audio effects processor, music synthesizer or sound analyzer or other projects of student interest. Weekly meetings and progress reports are required. Prerequisite: ECE 241; strong MATLAB expertise, and C/C++ programming familiarity (ECE 111 and ECE 113 recommended) (F)

AME 295 Audio Electronics Portfolio - This is a follow on course to AME223, Audio Electronics. In this course students will complete a major design/build project in the area of audio electronics. Examples include a solid state or tube-based instrument amplifier, audio power amplifier, audio effects processor, audio analog/digital interface or any other audio electronic project with the agreement of the instructor. Weekly meetings and progress reports are required. Prerequisite: AME 223 (F)

AME 386 Senior Design Project 1 - Senior Design Project in Audio and Music Engineering. In this first semester of the year-long AME Senior Project course students will define their product, possibly in collaboration with an outside customer, and then develop product concept documentation, detailed requirements specifications, system level designs, detailed sub-system designs and hopefully build demonstration prototypes. (F)

AME 387 Senior Design Project 2 - Senior Design Project in Audio and Music Engineering. In the second semester of the year-long AME Senior Project course students will complete their projects including final system level designs, detailed sub-system designs, prototype building, testing, evaluation and final presentation to the customer. Prerequisite: AME 386 (S)

AME 391 Applied Recording Arts - In this course students will complete a recording, mixing and mastering project leading to production of professional grade audio content. Students may choose to make a live recording of one of the River Campus music ensembles, of their own ensemble, or they may make a studio recording with available facilities. Other project possibilities include recording and producing sound for picture. Frequent planning meetings with a faculty advisor and progress reports are required. Final course evaluation will be based on the quality of the finished product. Prerequisite AME 191 (F/S)
AME 393  Applied Sound Design - In this course students will complete a major Sound Design independent project culminating in a live machine assisted music performance or an entirely machine generated music performance. Other possible projects include live gallery-based sound installations, web-based music projects, film/video scoring, voice over and sound effects or any other creative endeavors in the area of sound design. Frequent planning meetings with a faculty advisor and progress reports are required. Final course evaluation will be based on the quality of the finished product. Prerequisite AME 193    (F/S)

AME 460  Digital Programs and Programing I - The course is intended to provide students a basic understanding of sound design, and working with sound for picture. The emphasis is on demonstrations and hands-on experience to enable students to gain a practical knowledge of sound and music production using computers. Topics include MIDI; synthesizers & samplers; recording and editing with Pro Tools and Logic Pro X; sound effect creation; foley & automatic dialog replacement; basic soundtrack composition; and working to picture. Many techniques are explored employing software and hardware based sound creation tools throughout the course. Students will complete a major project at the conclusion of the course. Prerequisite: Basic Music Theory, Basic Piano    (F/S)

AME 461  Digital Programs and Programming II - The course emphasizes hands-on experience where students gain practical skills in scoring to picture using digital audio workstations. It features guest lectures by industry leading professionals, who will share their insights on creating music for TV Shows, Advertising, Movies, Gaming, Animation, and Industrial Work. Topics also include soft synthesizers, samplers and virtual instruments; recording and editing with Pro Tools and Logic; and sound design on audio workstations. Students will complete a number of projects throughout the course. Prerequisite : AME 460    (F/S)

MUR 101  Elements of Music - A course for the student with no previous musical experience. Topics covered include notation, intervals, chords, and other basic concepts of tonal harmony, with application to the study of a wide range of styles including popular idioms. Students should not be able to read music. (F/S)

MUR 109  Musicianship I: Literacy Skills - Introduces students to basic musicianship skills. Begins with exercises in pitch matching and basic interval recognition and progresses toward other skills, such as singing simple melodies at sight, sight-reading various rhythmic patterns, and dictating simple melodies and chord progressions. Prospective music majors, especially those with prior singing experience, typically skip this course and begin with MUR 113. (F/S)

MUR 110  Introduction to Music Theory - Basic concepts addressing students with previous experience in an instrument or voice and little music theory. Scales, keys, intervals, chords, basic part-writing, and other fundamental aspects of musical structure. Some ear training and aural skills. Prerequisites: Ability to read music, preferably in both treble and bass clefs. Students completing MUR 101 should NOT register for MUR 110    (F)

MUR 111  Theory I - The first in a four-course sequence. Deals with basic elements of harmony, voice-leading, and analysis. Part-writing in chorale style teaches elementary aspects of tonal theory. Prospective music majors should begin their theory requirement with this course. Prerequisites: MUR 101, 110 or permission of instructor (placement test)    (F)

MUR 112  Theory II - Continuation of MUR 111. This course continues with chorale and keyboard-style harmony exercises, but also introduces chromaticism, modulation, and analysis of form and phrase structure. Prerequisite: MUR 111    (S)

MUR 113  Musicianship II: This course develops basic musicianship skills with an emphasis of diatonic sight-singing, rhythmic sight-reading, and dictation of diatonic melodies and chord progressions. The exercises and in-class activities are similar to MUR 109 but at a more advanced level    (F/S)

ECE 114  Introduction to C/C++ Programming - This course provides an introduction to the C and C++ programming languages and the key techniques of software programming in general. Students will learn C/C++ syntax and semantics, program design, debugging, and software engineering fundamentals, including object-oriented programming. In addition, they will develop skills in problem solving with algorithms and data structures. Programming assignments will be used as the primary means of strengthening and evaluating these skills    (F/S)
\bf{ECE 210  Circuits and Microprocessors for Scientists and Engineers} - Circuit analysis considering passive RLC elements, ideal and controlled sources, op-amps, steady state and transient response, transfer functions, filters, LaPlace transforms, Fourier series. Intended for engineering and science students not majoring in Electrical and Computer Engineering.  \textbf{Prequisite: Concurrent registration in MTH 165 and PHY 122}  (S)

\bf{ECE 221  Electronic Devices and Circuits} - Introduction to the physics and operation of semiconductor devices and to the design and analysis of basic electronic circuits.  Semiconductor transport properties, P-n junction diodes and diode circuits.  Bipolar junction transistors.  Single- and multi- stage BJT amplifiers.  Differential amplifiers.  Small-signal analysis, bias design, time and frequency response of BJT circuits.  Laboratory  \textbf{Prerequisites: ECE 113 or ECE 210}  (F)

\bf{ECE 241  Signals} - Introduction to continuous and discrete time signal theory and analysis of linear time-invariant systems.  Signal representations, convolution, Fourier analysis, filtering of continuous and discrete time signals, Laplace and Z transforms.  Laboratory.  \textbf{Pre-requisites: MTH 165 and ECE113 or ECE210}  (F)
## CONTACT INFORMATION

### AME Advisors

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### AME Program Chair

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