The Electric Guitar as a Gateway to Electroacoustics

Instructor: P. Robert Kotiuga  
Office: PHO 523  
Office hours: Monday and Wednesday after class, or by appt.  
Tel: (617) 353-4151 (don’t bother with messages) E-mail: prk@bu.edu (most effective)

Location and time:  
ENG EK 131 EB: MW 10:10-11:55 AM in PSY B42. UTF: Nickholas Rodriguez  
ENG EK 131 MC:MW 12:20-2:05 PM in EPC 204, Michael (Hugo) Lindsay.  
Opportunity announcements to work on projects in PHO 105 and EPIC are forthcoming.

Catalog course description:  
The electric guitar evolved concurrently with the electrical reproduction of recorded music. This hands-on course uses the electric guitar as a gateway to musical acoustics and electro-acoustics. Before considering how electronics and amplifiers have become an integral “part of the instrument”, we review the basics of hearing, musical scales, resonance and the fundamentals of fretted string instruments. By examining the notions of distortion, compression, and feedback, an understanding is developed, of how the rock guitarist’s effects and multi-track recording are antithetical to the audiophile’s quest. This also provides a means of distinguishing “hi-fi” from various notions of “good sound”. 
The course will be supported by field trips, demos and labs.

Informal course objective:  
Take musically inclined Eng, Math, and Sci students, and turn ‘em into TRUE GEEKS!

Evaluation:
Homeworks & 2 questionnaire responses  
Attendance/Participation in both class and field trips  
Formal proposal for individual final paper/project  
Presentation on individual final paper or project  
Attending colleagues’ presentations  
Contribution to a “spoof” or a class project requiring “teamwork”  
Final (10 page) paper or project (with 5 page “diary”)  
Total  

15  
15  
10  
10  
5  
10  
35  
100

Notes:
1) In EK 131 there is less stress at the end of the module since it doesn’t coincide with final exams. Although undertaking a project and a paper should be an equal amount of work, a project in EK 132 can be trickier because “Murphy’s Law” seems to affect projects more than papers.
2) There is a possibility of collecting 5 extra bonus points for people showing exceptional initiative and leadership in the context of group projects. So, in some sense, the total is effectively out of 105.
### Rough Syllabus Week by Week

<table>
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<tr>
<th>By week</th>
<th>Specifics</th>
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<tr>
<td><strong>Week 1 class objective</strong></td>
<td>Outline course, provide context and review syllabus; have students provide a first pass at answers to the first questionnaire; Give an overview of project and paper expectations.</td>
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<td><strong>Week 1 Documentary</strong></td>
<td>« Tom Dowd and the Language of Music, 2003 » ... a film by Mark Moorman</td>
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<td><strong>Week 1 field trip</strong></td>
<td><strong>The Guitar Center</strong> 1255 Boylston St, Boston, MA 02215</td>
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<td><strong>Week 2 class objective</strong></td>
<td>Ideal strings, harmonics, the math behind well-temperament, decibels and “back of the envelope calculations”</td>
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<td><strong>Week 2 Documentary</strong></td>
<td>« The Music Instinct : Science and Song », 200, a film by Elena Mannes ; Bobby McFerrin and Daniel Levitin hosts (see note 1)</td>
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<td><strong>Week 2 Field trip</strong></td>
<td><strong>Boston MFA: Stringed instruments collection</strong></td>
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<td><strong>Week 3 class objective</strong></td>
<td>Discussion of project possibilities, pitfalls; a discussion of room acoustics and the notion of “listening”; questionnaire 3.</td>
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<td><strong>Week 3 Documentary</strong></td>
<td>« Restoration Stories; The BU Symphonic Organ. » (see note 2) ; Landfilharmonic, and other explorations of understand able musical instruments</td>
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<td><strong>Week 3 field trip</strong></td>
<td><strong>Physical resources for projects, BU CoE Labs (beyond the Imagineering Lab), ECE: “Circuits and electronics” (PHO 105), Radio Shack. BU Symphonic organ in the GSU (to continue the discussion of recorded music).</strong></td>
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<td><strong>Week 4 class objective</strong></td>
<td>Begin project presentations and lecture material in support of projects.</td>
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<tr>
<td><strong>Week 4 Documentary</strong></td>
<td>See note 3</td>
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<td><strong>Week 4 field trip</strong></td>
<td><strong>Local store catering to audiophiles;</strong> Audio Concepts, Comm Ave, or Goodwins High End (Waltham).</td>
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<td><strong>Weeks 5 &amp; 6 class objective</strong></td>
<td>Continue project presentations and lecture material in support of projects. Project demos; spoof.</td>
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1) This movie was inspired by Daniel Levitin’s book (see below) and the director has a 2011 follow-up book called: « The Power of Music »
2) See website … and related stories in Bostonia … and BU Today…….
3) Additional documentaries are dictated by class interest. For instance, if the “music and the brain theme takes off, the documentary, « Touch the Sound; a Sound Journey with Evelyn Glennie », becomes a must.
Required text:

Sir James Jeans "Science and Music," Dover Publications, 1968, ISBN 9780486619644. This book is a masterful popular exposition written by a leading scientist, in the 1930s (!) when electroacoustics was an exploding field. (Although the telephone and radio were established technologies in the 30s, talkies, TV, tape recording, electric musical instruments, and sonar were rapidly driving technological improvements). Although some physiological aspects are dated, the book teems with very concrete explanations.

This is the only required text. Enjoy it! Numerous other books and online resources will be suggested on an “as needed basis”, but two favorites are …

(Totally optional) References (depending on your interests):

… In the last 20 years functional MRI (fMRI) has revolutionized how we understand the brain. In particular, it has enabled us to understand our passion for music in terms of medical imaging. This NYT best-seller brought these advances to the general public.

… Although electric guitar enthusiasts might go through the entire book, lectures and projects only scratch the surface. See pages: 49-59 for “Electric Guitars”, 182-196 for “Guitar Maintenance and Customizing” and 198-224 for “Performance Technology” … In general, for electric guitars, I urge you to use online resources.

Potential/Additional Field Trips for weeks 5 & 6 …depending on class interest:

* A facility for recording and archiving music; for example the BU’s Mugar Library Music Collection, Harvard Music Library, BU’s CFA, or a local FM station with facilities for live recording, such as WGBH or WBUR.
* Boston Symphony Hall: for acoustics and recording facilities
* Mix-One Studios; one of New England’s premiere recording studios
* Berklee College of Music; Music Production &Engineering dept.
Some technical topics which get emphasized in class:
- Consonance, dissonance and the math behind well-temperament
- The decibel scale, log frequency scale, the idea of a Bode plot
- Music recording and (re)production: “Good Sound” vs. “Hi Fi”
- Hearing, music and the brain
- “String theory for Engineers and Musicians”…

…and more advanced topics which are addressed “as needed”:
- Basics of circuits and electronics
- Electric guitar pickups and loudspeaker construction
- Acoustic resonance, cavities and transmission lines
- Amplifiers, distortion, music reproduction, compression of dynamics

In general, your four year degree does not leave sufficient time to explore all technical topics that might relate to this course; we have to make choices! If there is a technical topic that is particularly useful for developing your paper or constructing your project, let me know and I’ll see what I can do working it into the broader themes covered in class.

Topics that lead to possible labs and class demos:
Distinction between chromatic and well-tempered scales illustrated via “beats”; signal generators, Lissajous figures, oscilloscopes, and beats; harmonics on strings and spectrum analysis; The circle of fifths and the circular slide rule; Experiments with coupled and/or electromagnetically driven tuning forks; resonance; Equations involving string density, length, tension, and oscillation frequency. Speed of sound, phase response, feedback and (in)stability; Room acoustics; reverberation time; decibel scale and Bode plots; Guitar effects pedals, distortion circuits (depending on student interest); ties to engineering software: Matlab, Simulink, LabView.