ARIZONA STATE UNIVERSITY

GENERAL STUDIES COURSE PROPOSAL COVER FORM

Course information:

*Copy and paste **current** course information from Class Search/Course Catalog.*

College/School: College of Liberal Arts and Sciences | Department: **Physics**

Prefix: **PHS** | Number: **194** | Title: The Science of Musical Instruments | Units: 4

Is this a cross-listed course? No | If yes, please identify course(s)

Is this a shared course? No | If so, list all academic units offering this course

*Note- For courses that are crosslisted and/or shared, a letter of support from the chair/director of **each** department that offers the course is required for **each** designation requested. By submitting this letter of support, the chair/director agrees to ensure that all faculty teaching the course are aware of the General Studies designation(s) and will teach the course in a manner that meets the criteria for each approved designation.*

Is this a permanent numbered course with topics? No

If yes, all topics under this permanent numbered course must be taught in a manner that meets the criteria for the approved designation(s). It is the responsibility of the chair/director to ensure that all faculty teaching the course are aware of the General Studies designation(s) and adhere to the above guidelines.

Chair/Director Initials _____ (Required)

Course description:

Requested designation: Natural Sciences-SQ **Mandatory Review:** No

*Note- a **separate** proposal is required for each designation.*

Eligibility:

Permanent numbered courses must have completed the university's review and approval process. For the rules governing approval of omnibus courses, contact Phyllis.Lucie@asu.edu.

Submission deadlines dates are as follow:

For Fall 2016 Effective Date: October 1, 2015 For Spring 2017 Effective Date: March 10, 2016

Area(s) proposed course will serve:

A single course may be proposed for more than one core or awareness area. A course may satisfy a core area requirement and more than one awareness area requirements concurrently, but may not satisfy requirements in two core areas simultaneously, even if approved for those areas. With departmental consent, an approved General Studies course may be counted toward both the General Studies requirement and the major program of study.

Checklists for general studies designations:

Complete and attach the appropriate checklist

- Literacy and Critical Inquiry core courses (L)
- Mathematics core courses (MA)
- Computer/statistics/quantitative applications core courses (CS)
- Humanities, Arts and Design core courses (HU)
- Social-Behavioral Sciences core courses (SB)
- Natural Sciences core courses (SQ/SG)
- Cultural Diversity in the United States courses (C)
- Global Awareness courses (G)
- Historical Awareness courses (H)

A complete proposal should include:

- ☒ Signed course proposal cover form
- ☒ Criteria checklist for General Studies designation(s) being requested
- ☐ Course catalog description
- ☒ Sample syllabus for the course
- ☒ Copy of table of contents from the textbook and list of required readings/books

It is respectfully requested that proposals are submitted electronically with all files compiled into one PDF.

Contact information:

Name: Alicia Hawley | E-mail: anhawley@asu.edu | Phone: 480-965-6794

Department Chair/Director approval: *(Required)*

Chair/Director name (Typed): Dr. Peter Bennett Date: 3/15/16

Chair/Director (Signature): P. Bennett

Arizona State University Criteria Checklist for

NATURAL SCIENCES [SQ/SG]

Rationale and Objectives

Public scientific literacy, critical for sound decisions on scientifically infused issues such as climate change, includes understanding of basic science concepts, such as the fundamental behavior of matter and energy. It also includes the understanding that "science" is not an encyclopedic collection of facts. Rather, it is a process of exploration that embraces curiosity, inquiry, testing, and communication, to reduce uncertainty about nature. Absent understanding of scientific concepts and of the nature of science, science and pseudoscience are difficult to distinguish, and normal scientific disagreements may be misinterpreted as ideological or political disputes. The goal of the natural sciences (SQ/SG) requirement, including the laboratory requirement, is to instill understanding of basic science content and of the nature of science in every ASU graduate.

10/1989
REV: 1/1991, 3/1991, 1/2000, 10/2008, 4/2014

Proposer: Please complete the following sections and attach appropriate documentation.

ASU--[SQ] CRITERIA

I. - FOR ALL *QUANTITATIVE* [SQ] NATURAL SCIENCES CORE AREA COURSES, THE FOLLOWING ARE CRITICAL CRITERIA AND MUST BE MET:

YES	NO		Identify Documentation Submitted
☒	☐	**A.** Course emphasizes the mastery of basic scientific principles and concepts.	Syllabus
☒	☐	**B.** Addresses knowledge of scientific method.	Syllabus
☒	☐	**C.** Includes coverage of the methods of scientific inquiry that characterize the particular discipline.	Syllabus
☒	☐	**D.** Addresses potential for uncertainty in scientific inquiry.	Syllabus
☒	☐	**E.** Illustrates the usefulness of mathematics in scientific description and reasoning.	Syllabus
☒	☐	**F.** Includes **weekly** laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	Syllabus Addendum 1
☒	☐	**G.** Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	Syllabus
☒	☐	**H.** Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	Syllabus

II. - AT LEAST ONE OF THE FOLLOWING ADDITIONAL CRITERIA MUST BE MET WITHIN THE CONTEXT OF THE COURSE:

☒	☐	**A.** Stresses understanding of the nature of basic scientific issues.	Syllabus
☒	☐	**B.** Develops appreciation of the scope and reality of limitations in scientific capabilities.	Syllabus
☐	☐	**C.** Discusses costs (time, human, financial) and risks of scientific inquiry.	

NOTE: CRITERIA FOR [SG] COURSES BEGIN ON PAGE 4.

III. - [SQ] COURSES MUST ALSO MEET THESE ADDITIONAL CRITERIA:			
YES	**NO**		**Identify Documentation Submitted**
☒	☐	**A.** Provides a substantial, quantitative introduction to fundamental principles governing behavior of matter and energy, in physical or biological systems.	Syllabus
		B. Includes a college-level treatment of some of the following topics **(check all that apply below):**	
☐	☐	**a.** Atomic and molecular structure	
☐	☐	**b.** Electrical processes	
☐	☐	**c.** Chemical processes	
☐	☐	**d.** Elementary thermodynamics	
☒	☐	**e.** Electromagnetics	Syllabus
☒	☐	**f.** Dynamics and mechanics	Syllabus
[SQ] REQUIREMENTS CANNOT BE MET BY COURSES:			
• **Presenting a qualitative survey of a discipline.**			
• **Focusing on the impact of science on social, economic, or environmental issues.**			
• **Focusing on a specific or limiting but in-depth theme suitable for upper-division majors.**			

Proposer: Please complete the following section and attach appropriate documentation.

ASU--[SG] CRITERIA

I. - FOR ALL *GENERAL* [SG] NATURAL SCIENCES CORE AREA COURSES, THE FOLLOWING ARE CRITICAL CRITERIA AND MUST BE MET:

YES	NO		Identify Documentation Submitted
☒	☐	**1.** Course emphasizes the mastery of basic scientific principles and concepts.	Syllabus
☒	☐	**2.** Addresses knowledge of scientific method.	Syllabus
☒	☐	**3.** Includes coverage of the methods of scientific inquiry that characterize the particular discipline.	Syllabus
☒	☐	**4.** Addresses potential for uncertainty in scientific inquiry.	Syllabus
☒	☐	**5.** Illustrates the usefulness of mathematics in scientific description and reasoning.	Syllabus
☒	☐	**6.** Includes **weekly** laboratory and/or field sessions that provide hands-on exposure to scientific phenomena and methodology in the discipline, and enhance the learning of course material.	Syllabus Addendum 1
☒	☐	**7.** Students submit written reports of laboratory experiments for constructive evaluation by the instructor.	Syllabus
☒	☐	**8.** Course is general or introductory in nature, ordinarily at lower-division level; not a course with great depth or specificity.	Syllabus

II. - AT LEAST ONE OF THE ADDITIONAL CRITERIA THAT MUST BE MET WITHIN THE CONTEXT OF THE COURSE:

☒	☐	**A.** Stresses understanding of the nature of basic scientific issues.	Syllabus
☒	☐	**B.** Develops appreciation of the scope and reality of limitations in scientific capabilities.	Syllabus
☐	☐	**C.** Discusses costs (time, human, financial) and risks of scientific inquiry.	

[SG] REQUIREMENTS CANNOT BE MET BY COURSES:		
	• Presenting a qualitative survey of a discipline.	
	• Focusing on the impact of science on social, economic or environmental issues.	
	• Focusing on a specific or limiting but in-depth theme suitable for upper-division majors.	

Course Prefix	Number	Title	General Studies Designation
PHS	194	The Science of Musical Instruments	SQ

Explain in detail which student activities correspond to the specific designation criteria. Please use the following organizer to explain how the criteria are being met.

Criteria (from checksheet)	How course meets spirit (contextualize specific examples in next column)	Please provide detailed evidence of how course meets criteria (i.e., where in syllabus)
I.A	Students master basic scientific principles and concepts in homework, classwork, and laboratory.	Syllabus Addendum 1
I. B.	Scientific Method is used primarily in the laboratory portion of the course.	Syllabus: Science topics, and Syllabus: Weekly Labs Addendum 1
I.C.	Students use scientific inquiry when problem solving and in the laboratory.	Syllabus: Science topics, and Syllabus: Weekly Labs Addendum 1
I.D.	Students analyze measurement unscertainty in their laboratory data.	Syllabus: Weekly Labs Addendum 1

Course Syllabus: PHS 194
The Science of Musical Instruments

Instructor: Robert Culbertson (robert.culbertson@asu.edu) (480) 965-0945

Course Description and Goals

The Science of Musical Instruments is a science class set in a musical context. As you learn about music, musical instruments you will also learn about the underlying scientific and mathematical principles. You will be amazed by the variety of scientific principles that can be seen in an instrument as simple as a guitar or flute!

Rather than a focus on lecture to deliver information, *The Science of Musical Instruments* is a science course that emphasizes the student-lead dialogues, the utilization of data collection and analysis software, the de-emphasis on rote memorization, and de-emphasis of multiple-choice formats for questions as we proceed through the semester. Student may utilize these strategies in their own classrooms as they are based on research.

Student Learning Outcomes

Students completing The *Science of Musical Instruments* will be able to describe the harmonic behavior of vibrating strings, air columns, and bars and will be able to design a musical instrument based on scientific nature of strings, air columns, or bars capable of playing a major scale.

Science topics

- The Nature of Science and Scientific Method
- Energy and power
- Types of waves
- Simple Harmonic Motion
- Sound and vibrations
- Harmonic systems
- Constructive and destructive interference
- Standing waves
- Modes
- Nodes and anti-nodes
- Wave transmission and reflection through materials
- Acoustic impedance
- Electrical circuits and basic electrical components

Mathematics topics

- Function
- Trigonometric ratios
- Exponents
- Roots
- Logarithms

- Making and interpreting graphs
- Mathematically modeling physical phenomena

Music topics and ideas:
- Musical scales
- Intervals
- Beats
- Note identification
- The keyboard
- Timbre
- Pitch
- Consonance and dissonance

Textbook and software

Lapp, David. *The Physics of Music and Musical Instruments.* Free download *HERE*.

Supplementary readings in addition to those found in the textbook will be provided from time to time.

Students will make extensive use of *Microsoft Excel* (or *OpenOffice*, etc.), *Audacity*, and *LoggerPro* as the semester progresses. *OpenOffice* may be downloaded from http://openoffice.org. *Audacity* may be downloaded for free from http://audacity.sourceforge.net/

Grading
Homework: Homework will be given once or twice each week, and grading will primarily be based on effort.

Quizzes: Expect at least one quiz every week. At times the quizzes will be announced, and sometimes they will not be announced.

Weekly Labs and lab reports: Lab reports will be written for some, but not all lab experiences. Quantification of measurements, including uncertainties, will be emphasized. Goggles and closed-toes shoes are required for lab!

Final project: Students will have the opportunity to build their own musical instrument as a final project. Each student will describe and demonstrate their instrument in the Final Recital from 12:10 – 2:00 on Tuesday December 9, 2014.

Exams: One mid-term exam will be given.

Participation: Attendance, participation in class, daily surveys, and participation on the Wiki count toward the Participation grade.

Grades will be weighted as follows:

Category	Weight
Homework	10%
Participation	15%
Quizzes	10%
Laboratory	25%
Midterm	15%
Final Recital	25%

Class Discussions

Extensive use will be made of white boards and student discussion in the class. The instructor will serve to guide and facilitate student learning.

Example Schedule

PHS 110 Fall 2014 12:00 - 2:45 PSH 357					
Date	**Day**	**Class**	**Unit**	**Topic**	**Readings**
21-Aug	Th	1	1	Intro	Intro handouts; textbook introduction
26-Aug	Tu	2			
28-Aug	Th	3			
2-Sep	Tu	4	2	Mechanical Waves	Chapter 1 and 2
4-Sep	Th	5			
9-Sep	Tu	6			
11-Sep	Th	7	3	Propagation of Sound	Periodic Longitudinal Waves
16-Sep	Tu	8			
18-Sep	Th	9			
23-Sep	Tu	10	4	Modes...	Chapter 3
25-Sep	Th	11			
30-Sep	Tu	12	5	Musical Scales	Chapter 4
2-Oct	Th	13			
7-Oct	Tu	14	6	Strings	Chapter 5
9-Oct	Th	15			
14-Oct	Tu			*Fall Break*	
16-Oct	Th	16			
21-Oct	Tu	17	7	Aerophones I	Chapter 6
23-Oct	Th	18			
28-Oct	Tu	19			Chapter 7
30-Oct	Th	20	8	Aerophones II	
4-Nov	Tu	21	9	Percussion	
6-Nov	Th	22	10	Electricity	
11-Nov	Tu			*Veterans Day (No Class)*	
13-Nov	Th	23	11	Magnetism	
18-Nov	Tu	24			
20-Nov	Th	25			
25-Nov	Tu	26			
27-Nov	Th			*Thanksgiving (No Class)*	
2-Dec	Tu	27	12	Elect/Electron. Instrum.	
4-Dec	Th	28		Last Class	
9-Dec	**Tu**			**Final Project Presentation 12:10 - 2:00 pm**	

General Classroom Policies

Safety: A safe classroom environment must be maintained at all times. *Close toed shoes* and *safety glasses* must be worn when using tools.

Academic Integrity: Academic honesty is expected of all students in all examinations, papers, laboratory work, academic transactions, and records. The possible sanctions include, but are not limited to, appropriate grade penalties, course failure (indicated on the transcript as a grade of E), course failure due to academic dishonesty (indecated on the transctipt as a grade of XE), losss of registration privileges, disqualification and dismissal. For more information, see http://provost.asu.edu/academicintegrity.

Conduct: Disruptive behavior will not be tolerated. Students are required to follow the ASU Student Code of Conduct: Arizona Board of Regents Policies 5-301 through 5-308: http://www.asu.edu/aad/manuals/ssm/ssm104-01.html

Computer Policy: Computers and related equipment are used in class for course-related work only - checking email, updating Facebook, etc. will result in a zero on the weekly quiz. Students must be in compliance with the ASU Computer, Internet, and Electronic Communications Policy:
http://www.asu.edu/aad/manuals/acd/acd125.html

Cellular Phones, etc.: No cellular phones, etc. may be used during class. No placing calls, receiving calls, or text messaging is permitted, and a zero will be given on the weekly quiz for the first offense. A warning will be given for the first audible interruption. The second offense will result in the equivalent of a zero on one quiz. A student will be expelled from the course for the third offense.

Disability Resources Center: If you believe you have a qualified disability, please see the Disability Resources Center to learn what accommodations you may or may not be entitled to. http://www.asu.edu/studentaffairs/ed/drc/

Changes to the Syllabus. Note that this syllabus may be changed from time to time. The class will be notified should any changes to the syllabus occur.

Addendum 1

Summary of PHY 194 Labs

Title: Pendulum Lab

Objectives: Determine the dependence of the period of a pendulum on length, mass, and amplitude.

Features: Independent and dependent variables; linearizing data; frequency and period; using a spreadsheet; experimental error.

Title: Mass-Spring Oscillations

Objectives: Determine the dependence of the frequency of a mass-spring system on mass and spring stiffness.

Features: Hooke's law; sinusoidal behavior.

Title: Monochord Lab

Objectives: Use the engineering design process to design and construct a monochord (a simple single-string instrument); discover special relationships for sounds from strings with certain length ratios (octave, 2:1 and perfect fifth, 3:2); develop Pythagorean scheme for dividing an octave into 12 steps.

Features: Engineering design process; octave perfect fifth intervals; spreadsheets with "IF" function; frequency spectrum; harmonics; harmonic series.

Title: Intensity Lab

Objectives: Determine a relationship between light intensity and distance from the light source.

Features: Students "discover" the inverse-square law for light; includes extensions to sound: sound intensity and sound level (decibels).

Title: Guitar Lab

Objectives: Discover a rule to determine the placement of frets on a fretted instrument such as a guitar: measure the effective string length for each fret; determine the frequency of the first harmonic for each string length.

Features: Exponential behavior; equal temperament; depreciation and compound interest.

Title: Speed of Sound

Objectives: Determine the speed of sound in air.

Features: Wave equation f = v*l, where f, v, and l are frequency, speed, and wavelength. Harmonics in air column with open/close ends; end effect; odd harmonics.

Title: Pan Pipes

Objectives: Use the engineering design process to design and construct a simple open/closed PVC pipe musical instrument to cover a major scale over one octave.

Features: Engineering design process; open/closed air column; end effect; just intonation; major scale.

Title: Wind Chimes

Objectives: Use the engineering design process to design and construct a simple set of wind chimes.

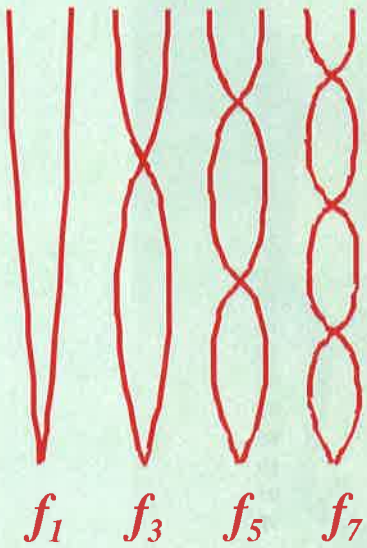
Features: Modes of vibrations of a bar, tube, pipe, etc., non-harmonic systems.

Title: Synthesis of Musical Sounds

Objectives: Use a program such as Audacity to simulate the sound of a plucked string; code a simple melody in a system such as Sonic Pi.

Features: Attack-decay-sustain-release; basic computer programming.

THE PHYSICS OF MUSIC AND MUSICAL INSTRUMENTS



DAVID R. LAPP, FELLOW
WRIGHT CENTER FOR INNOVATIVE SCIENCE EDUCATION
TUFTS UNIVERSITY
MEDFORD, MASSACHUSETTS

TABLE OF CONTENTS