University of Glasgow | School of Physics & Astronomy

PHYS1020 The Science of Musical Instruments and Acoustics

Course Information Guide 2023-24

1 Course Details

Course Head	Dr. Ken Livingston	Schedule	Mon 14:00 – 17:00
SCQF Credits	20	ECTS Credits	
Assessment	Examination (50%) Reports (50%)	Co-requisites	None
Level	Level 1 (SCQF 7)		
Typically Offered	Semester 2	Prerequisites	None

2 Assessment

Examination 50%

A final examination will be held in the April/May exam diet to test whether students have achieved the course intended learning outcomes.

Report 50%

The students will be required to provide written reports (ca. 1500 words), describing two of the activities carried out in the workshop.

3 Course Aims

The course aims to develop an understanding of the nature of musical sound and the basic physics governing the behaviour of musical instruments and acoustics. It also introduces basic measurement and analysis techniques and builds report writing skills. This is open to students from all colleges. The course is delivered through a combination of lectures, demonstrations, workshops and visits.

4 Intended Learning Outcomes

By the end of the course students will be able to:

1. Waves

(a) Draw a diagram of a wave labelled with amplitude and wavelength.

(b) Explain the difference between transverse and longitudinal waves.

(c) State and use the wave equation ($v = f \lambda$), and the relationship between period and frequency ($T = 1/f$).

(d) Draw a diagram of a standing wave labelled with node and antinode.
(e) State that standing waves arise due to the superposition of a wave with its reflection.
(f) Explain the difference between time domain and frequency domain.

2. Sound and music

(a) State that sound is a longitudinal, pressure wave, and travels at approx 340m/s in air.
(b) Draw a schematic diagram of the human ear and explain the functions of the different parts.
(c) State the approximate range of human hearing.
(d) State that musical instruments produce standing waves.
(e) Explain the relationship between measured wave quantities and perceived sound (loudness/amplitude, pitch/fundamental frequency, timbre/spectrum+envelope).

3. Scales

(a) State that notes whose frequencies are ratios of small numbers sound "better" together, and this is the basis of musical scales.
(b) Explain the terms "just intonation" and "just interval".
(c) Explain the pythagorean scale, and the pythagorean comma.
(d) Explain the term "temperament".
(e) Describe the difference between a diatonic and chromatic scale.
(f) Discuss the advantages and disadvantages of the 12-EDO scale.

4. Instruments

(a) Explain timbre in terms of spectrum and envelope.
For each class of instrument (stringed, wind, brass, voice and percussion):

i. Draw a diagram illustrating the means of sound production.
ii. Describe the way in which sound is produced.
iii. Discuss the differences between instruments in the class. (eg single vs double reeded, bowed vs plucked)

(b) Measure and discuss the dynamic range and timbre of instruments using smart phone app and computer software.
(c) Explain how sound is generated in an electric guitar.
(d) Give examples of the methods of generating sounds in electronic instruments.
(e) Discuss the differences between acoustic and electronics instruments.

5. Architectural Acoustics

(a) State and use the formula giving the decibel difference between two sounds of a given intensity ratio, and define the Sound Pressure Level of a sound.
(b) Measure the SPL of a range of sounds using a meter, smartphone app or computer.
(c) Define the reverberation time of a room.
(d) Discuss the acoustical properties desirable in buildings (eg Concert halls, Opera houses, lecture rooms)
(e) Measure the reverberation time for a room by using a smartphone app, or meter.

6. Recording

(a) Draw a diagram of a loudspeaker, and explain how it works.
(b) Explain the difference between analogue and digital recording.
(c) Draw a diagram illustrating the conversion of an analogue to digital signal

(d) Discuss the advantages and disadvantages of digital and analogue recording.

(e) Discuss the relative environmental impact of listening to a track on vinyl and in lossless digital format.

7. Measurement and reporting.

(a) Demonstrate the use of audio measurement software tools on Android and Computer.

(b) Discuss the difference between systematic and statistical errors in measurement.

(c) Write a report of a workshop project

5 Course Outline

Lecture Course

The fundamentals of musical sound and acoustics will be covered using practical demonstrations, and with live recording and analysis of musical sounds. Students knowledge of the material will be assessed in written exam. (50% of course assessment)

Workshops

The workshops will provide the opportunity for students to investigate musical sound using techniques demonstrated in the lecture course. Recording and analysis of sounds will be done using the open-source Audacity software package. Practical work will be assessed via two written reports focusing on topics covered in the workshop (50% course assessment)

Visits

There will be two group visits to local buildings / concert halls with different acoustic properties. A short lecture will be given by someone with local knowledge and students will have the opportunity to make recordings and measure reverberation times.

The most recent visits were:
RSNO Clyde Auditorium – Tour and talk from Luke Roberston, Acoustic Engineer, ARUP
University Chapel Organ – Demo and talk from Kevin Bowyers, University Organist

These were very popular, and it is planned to repeat them in this year's course.

6 Further Information

Further information can be found on the course Moodle page.