Unit 1: Acoustics for Musicians

Unit code: J/600/6878

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to establish knowledge of acoustic principles related to music. Learners will become familiar with the principles of sound, musical instruments, human hearing and the acoustic characteristics of spaces.

Unit introduction

Acoustic principles are fundamental in establishing a deeper understanding of music production and performance. Many areas of work within the music industry require knowledge of these principles, including studio recording, live sound engineering and the design of musical instruments, sound studios and sound reinforcement systems.

From the principles of sound itself to the various methods musical instruments use to produce sound, the mechanisms of human hearing, to how we perceive sound in different acoustic spaces, a working knowledge of acoustics will help musicians and music producers in their quest to create better sounding music. Studio engineers should understand the effects of acoustic spaces on sound production in performance and the recording process from microphone placement through to accurate monitoring.

Acoustics is a large area of study so this unit focuses on the basics to inform the learner's musical work and possibly establish an interest in the area leading to study at a higher level. On completion of this unit, learners will have a grasp of the principles of sound and an awareness of the impact of acoustics on the creation of music. They will understand how sound behaves in a musical space, such as a studio control room, and will be able to suggest improvements to the acoustics of that space through measurements and calculation. Learners will also have an understanding of how musical instruments produce sound and the mechanics of human hearing.

Learning outcomes

On completion of this unit a learner should:

1 Know the physics of sound

2 Know the principles of musical instruments

3 Know the mechanisms of human hearing

4 Be able to adapt the acoustic characteristics of a space to suit a specific audio application.

Unit content

1 Know the physics of sound

Physics of sound: transmission of energy; sound waves; wavelength; frequency; amplitude; speed of sound; phase relationships; the decibel; sound pressure levels; harmonics; the harmonic series; harmonic content of waveforms

2 Know the principles of musical instruments

Musical instrument types: string; wind; percussion

Sound production methods: eg plucked, bowed, struck, blown, performance techniques

Physical construction: eg pipes, reeds, skins, construction materials

Musical attributes: pitch; amplitude; timbre; attack; sustain; decay

3 Know the mechanisms of human hearing

Mechanisms of human hearing: structure and function of the outer ear, middle ear and inner ear; ear damage; limits of hearing; sound pressure levels; psychoacoustics; health and safety

4 Be able to adapt the acoustic characteristics of a space to suit a specific audio application

Musical spaces: eg control room, live room, vocal booth, concert hall, music venue and theatre

Acoustic characteristics of spaces: listening room; stereo image; live room; live end – dead end (LEDE); absorption; reflection; diffusion; modal response; reverberation time; standing waves; colouration; comb-filtering;

Corrective procedures: acoustic treatment eg absorbers, traps, choice of building materials; basic soundproofing; speaker placement; system equalisation; listening position; reasons not to use corrective EQ in a studio

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	define the physics of sound	**M1**	explain the physics of sound	**D1**	assess the physics of sound
P2	define the principles of musical instruments	**M2**	explain the principles of musical instruments	**D2**	assess how the principles of musical instruments affect sound production
P3	define the mechanisms of human hearing	**M3**	explain the mechanisms of human hearing	**D3**	assess the mechanisms of human hearing
P4	adapt the acoustic characteristics of a chosen space to suit a specific music application with assistance. [IE, CT]	**M4**	adapt the acoustic characteristics of a chosen space to suit a specific music application with only occasional assistance.	**D4**	independently adapt the acoustic characteristics of a chosen space to suit a specific music application to near- professional expectations.

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Basic concepts involved in acoustics will need classroom or lecture activity to establish language, theory and conventions. Where possible, delivery should be based around practical demonstrations and exercises that encourage learners to experiment and listen to sounds, instruments and music. The science of acoustics should be used to explain what learners are hearing and how their perception of sound is influenced by internal and external factors rather than being the main focus of delivery. Learners will explore musical instruments and why they sound like they do. Learners should be able to explore how instruments produce sound from their different components and parts and how this creates different timbres. There can be a direct link made here between complex sound waves that have a rich harmonic content and how musical instruments create sound. This link is likely to be made once the topics have been explained by the learner so creating an opportunity to combine the depth of understanding needed to gain the highest grades in the first two grading criteria.

When studying the mechanics of the human ear there is again an opportunity to make links with acoustic principles such as sound pressure levels, frequency and harmonic content. There is a wealth of information online that explains the topic area using diagrams and easily understood text. There are also websites that offer hearing tests of sorts. Frequency ranges can be demonstrated using a signal generator in the classroom and different examples such as masking effects and reduced upper frequencies can be created using music recording software. The higher grades are likely to be reached through assessment of the damage to hearing during work as a musician and/or through psychoacoustics.

Learners will need access to spaces used for music recording and performance. Visits to music venues, churches and studios with some opportunity to record and/or talk to someone who works or performs there would greatly enhance the learner's experience. Case studies can be found online and in books that outline recording studio design projects showing where and why problems may exist and what measures can be put in place to solve them. When choosing a music space to use as part of an assignment it is important that the tutor has already found out the measurements and calculated acoustic properties, such as reverb time and modal response, to make sure that the space is a suitable case study for learners to use. It would be ideal, for example, to use a space that has problems with standing waves or one that has reflective surfaces that cause problems when listening to music. A good example to use would be a medium-sized classroom space that is either being used, or is planned to be used, as a recording studio control room where detailed listening will be done.

Learners will need classroom sessions to cover the topics related to room acoustics set out in the unit content. They will need detailed room dimensions and information on the material used to construct the chosen space to allow them to calculate the acoustic properties and suggest improvements. This part of the unit will link learners directly to acoustic principles, musical instruments and human hearing and links can be made when planning assessment.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to the unit.
Introduction to sound (see unit content). Practical demonstration/Audio Visual resources/worksheets.
Assignment 1: Physics of Sound – P1, M1, D1 • Introduce assignment. • Write: research in class.
The three musical instrument families – practical demonstration. Internet-based research into each instrument type.
Assignment 2: Musical Instruments – P2, M2, D2 • Introduce assignment. • Write: research in class.
Human hearing – the outer ear, middle ear and inner ear. Stereo hearing, psychoacoustics, the studio control room. Damage to hearing from loud music, legislation, protection.
Assignment 3: Human Hearing – P3, M3, D3 • Introduce assignment. • Write: research in class.
Basic room acoustics (see unit content). Case study – studio control room design. Visit a music room – measurements, calculations.
Assignment 4: Sound Studio Design – P4, M4, D4 • Introduce assignment. • Evidence: individual and small-group practical sessions. • Review: peer review and assessment feedback.
Review unit and assignments.

Assessment

The content and focus of this unit is flexible enough to allow assessment of each grading criterion separately or in combination.

Evidence for learning outcomes 1, 2 and 3 can be presented as a written report, website page, internet 'blog' or oral presentation. The use of worksheets and short tasks within classroom sessions will build both evidence and knowledge and in some cases this work may be suitable for presentation as evidence for assessment. Evidence should be generated in a practical manner, where possible alongside critical reflection and research. The critical reflection is a vital element of the unit for those learners wishing to meet the higher level grading criteria. At merit level learners will need to explain the different principles and concepts involved, while for distinction, learners will take these explanations to the next level. They will make links between concepts and principles, analysing and commenting on them.

Evidence for learning outcome 4 should be presented as a case study, using a suitable music space that will allow for measurements to be taken, issues to be identified and practical solutions to be suggested. Learners can work in small groups, but must clearly highlight in their evidence what elements were collaborative and the sources used in research.

When working on a practical activity learners working at pass level will require detailed guidance. They will complete the task but this is likely to be under fairly close direction from the tutor with little evidence of autonomous thinking. At merit level, learners will be able to cover most elements of the practical tasks with only minor guidance. For example, tutors might be asked for clarification of a specific task. At distinction level, learners are likely to be able to complete any practical tasks with little further information from the tutor. Asking questions (or not) is not a deciding factor when awarding distinction grades. At this level learners may well question things in far more detail (therefore showing a greater depth of understanding) than other learners who will complete the given tasks and assignments at face value.

To achieve P1, learners must define the physics of sound. Information is likely to be brief but should be accurate and use the correct terminology. It is likely to focus on answering the question: What is sound? With less detail placed on harmonic content of sound waves.

To achieve M1, learners must explain the physics of sound. Evidence is likely to include explanation of what sound is and how it travels, including details of important elements such as frequency, wavelength, phase relationships, sound pressure and the harmonic series. Diagrams may be used to help explain topics.

To achieve D1, learners must assess the physics of sound. A focus is needed that allows scope for assessment of the physics of sound. For example, a learner may assess the harmonic series in order to consider the harmonic content of a range of basic waveforms such as sine, square, triangle and sawtooth.

To achieve P2, learners will define the principles of musical instruments. Evidence could consist of labelled diagrams drawn or generated by the learner that accurately show how different musical instruments work, covering all families of instrument type detailed in the unit content.

To achieve M2, learners will explain the principles of musical instruments. The method of sound production by each of the three families of musical instruments should be explained. Topics include tuning, pitch, dynamics and tone.

To achieve D2, learners will assess how the principles of musical instruments affect sound production, comparing, for example, tone, sound quality, physical construction, materials used and playing techniques to other instruments in the same family or the other families.

To achieve P3, learners will define the three sections of human hearing including the inner, middle and outer ear.

To achieve M3, learners will explain the mechanisms of human hearing. The function of each section of the ear and the components within each section should be explained.

To achieve D3, learners will assess the mechanisms of human hearing and cover the impact of these mechanisms on acoustic music production. Learners may answer questions in their work such as: How and why should we protect our ears? How does damage occur? What are the different types of damage? Why do we have two ears? How do we hear in stereo? How and why do we hear in 3D? How does the listening environment impact on our aural perception?

To achieve P4, learners will, with assistance, adapt the acoustic characteristics of a chosen space to suit a specific music application. Evidence is likely to include the use of acoustic treatment but the placement and choice of materials may not be based on measurements taken or calculations. There should also be a brief description of some of the key elements of content relating to room acoustics as set out in the unit content.

To achieve M4, learners will, with only occasional assistance, adapt the acoustic characteristics of a chosen space to suit a specific music application. Evidence is likely show a direct link between the acoustic theories explained in their work and the suggested improvements to the acoustic of the space. Measurements have been taken and calculations made, for example room modes.

To achieve D4, learners will independently adapt the acoustic characteristics of a chosen space to suit a specific music application to near-professional expectations. Measurements and calculations will directly inform the adaptations made for improving the acoustics of the space for a specific purpose.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1, D1	Physics of Sound	As a sound technician, explain the basics of sound waves through to complex waveforms and the harmonic series.	Evidence comprising: • written report • presentation.
P2, M2, D2	Musical Instruments	Choose three different types of musical instrument and explain how they work.	Evidence comprising: • written report • presentation.
P3, M3, D3	Human Hearing	Explain how the mechanisms of human hearing and how our ears affect, or can be affected by, our work as a musician.	Evidence comprising: • written report • internet 'blog'.
P4, M4, D4	Sound Studio Design	Working as a sound studio designer it is your job to improve the sound quality of a chosen music space.	Evidence comprising: • written report • presentation.

Links to other BTEC units

This unit forms part of the BTEC Music and Music Technology sector suite. This unit has particular links with the following unit titles in the BTEC Music and Music Technology suite:

Level 1	Level 2	Level 3
		Audio Engineering Principles
		Listening Skills for Music Technologists
		Sound Creation and Manipulation

Essential resources

Learners will need access to a range of appropriate equipment and software used to demonstrate acoustic principles and measure acoustic spaces. Suitable resources include the internet, a signal generator, an oscilloscope, a test tone, music recording software, good quality monitors, headphones, a microphone, a slinky spring, a tape measure and a calculator.

Learners will also need access to a music recording and/or performance space that is suitable for measurements to be taken. For example, smaller rooms may be better suited for considering unwanted reflections and resonances while large spaces may be better suited for reverb time measurements. An acoustically well-designed space can be used but there will be more scope for learners to make improvements if the space has identifiable unwanted issues.

Employer engagement and vocational contexts

An understanding of acoustic will be beneficial to all musicians and music producers. It is specific to acoustic design for music studios and performance venues, environmental health, musical instrument design and music software design.

Delivery of personal, learning and thinking skills (PLTS)

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	interpreting information regarding the acoustic properties of a chosen musical space and relating it to class notes and research
Creative thinkers	using information, measurements and calculations to assess the acoustic properties of a musical space and suggest improvements to the sound of that space.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	researching topics online and through reading books, journals and prepared handouts
Reflective learners	reviewing topics covered through class discussion and small-group work
Team workers	working in small groups to measure the dimensions of a music space then working on calculating the acoustic properties
Self-managers	managing own workload and meeting assignment deadlines
Effective participators	participating in group discussions, practical demonstrations and group work.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	researching topics online
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	selecting appropriate research material online
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	writing reports on the topics some of which are complex and involve detailed explanation, this will include pictures and text in various formats
Bring together information to suit content and purpose	presenting assignment work to the learner group using ICT
Present information in ways that are fit for purpose and audience	presenting assignment work to the learner group using ICT
Mathematics	
Draw conclusions and provide mathematical justifications	using measurements and calculations made of a chosen musical space to suggest improvements to the room acoustics
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	presenting work to the learner group and discussing topic areas
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing reports on the topics some of which are complex and involve detailed explanation.