Subject Description Form

Subject Code	AMA1D08
Subject Title	The Mathematics behind Music
Credit Value	3
Level	1
Pre-requisite / Co-requisite/ Exclusion	Nil
Objectives	The subject aims to explore the connection between music and mathematics. We will present basic concepts in music theory and introduce the mathematical tools and theories to describe music in a simple and intuitive way. The students will gain a deeper understanding of both music and mathematics from the subject.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. explain basic music theory concepts including pitch, scale, temperament, rhythm, chord and timbre and how they are related to mathematics. b. know how different music instruments produce their sounds and how mathematics can be used in designing, tuning and playing them. c. understand the mathematical tools used to describe and analyze music and apply them to simple examples. d. recognize the different branches of mathematics introduced in the subject and the role they play in the study of music. e. conduct self-learning and work with team members in searching relevant literature and present the findings.
Subject Synopsis/ Indicative Syllabus	1. Pitch and pitch class; arithmetic and geometric sequences; logarithm functions; equivalent classes. 2. Scales and temperament; Pythagorean scale; just intonation and equal temperament; rational and irrational numbers; continued fractions and approximation. 3. Musical rhythms from African drums to dance music; generating rhythms using Euclidean algorithm and Bjorklund's algorithm; describing rhythms by graphs. 4. Chords, harmony and Tonnetz; representing chords using lattices and geometry. Torus and other shapes of surfaces. 5. Variations of a musical theme; transposition and permutations; representing symmetry in music using groups. 6. Overtones and timbre; representing sounds by sinusoids and their sums.

<table>
<tr><td></td><td>7. Vibrations, frequency and sound of string, wind and percussion instruments; the mathematics behind the designing, tuning and playing of different instruments; strings of the violin and the harp; sizes of instruments in the string and the brass family; where to hit different percussion instruments when playing them and why.</td></tr>
<tr><td>Teaching/Learning Methodology</td><td>Lectures: Examples from various aspects of music will be presented in the lectures followed by introductions to the mathematical tools and theories to study and analyze them. There will be audio and video materials in each lecture and students will answer questions using online response systems. Students will be engaged in an active learning atmosphere in the lectures.

Tutorials: Students will work in groups on a set of problems and discussion questions related to the previous lecture guided by the tutor in tutorials. The problems will be similar to those in the test and exam. The discussion questions will encourage the students to think actively and share their knowledge and ideas.</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="6">Intended subject learning outcomes to be assessed (Please tick as appropriate)</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td></td></tr>
<tr><td>1. Participation</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>2. Test</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>3. Presentation</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>4. Exam</td><td>40 %</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Total</td><td>100 %</td><td colspan="6"></td></tr>
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Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Participation (20%): Students will answer questions in class during the lectures using online student response systems (e.g. uReply). The marks will be based on both participation (10%) and performance (10%) in answering the questions.

Midterm Test (20%): A 90-minute in class midterm test will contain multiple choice questions and short answer questions.

Presentation (20%): Students will be divided into groups of four to five and each group will give a presentation in the last two to three weeks of the semester. The lecturer will suggest a set of topics based on the course material. The students can also choose their own topics related to mathematics and music upon approval from the lecturer. The presentation should be 8-10 minutes long and marks will be given according to the content (10%), organization (5%) and performance (5%).

Final Exam (40%): The exam will also contain multiple choice questions and short answer questions. The questions will blend music theory with simple applications of mathematical tools introduced in class.</td></tr>
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Student Study Effort Expected	Class contact:	
	▪ Lectures	26 Hrs.
	▪ Tutorials	13 Hrs.
	Other student study effort:	
	▪ Reading reference materials	30 Hrs.
	▪ Research and preparation for presentation	40 Hrs.
	Total student study effort	109 Hrs.
Reading List and References	Science of Percussion Instruments, Thomas D. Rossing, World Scientific, 2000 Music and Mathematics: From Pythagoras to Fractals, Edited by John Fauvel, Raymond Flood and Robin Wilson, Oxford University Press, 2003 The Discovery of Musical Equal Temperament in China and Europe in the Sixteenth Century, Gene J. Cho, Edwin Mellen Press, 2003 The Mathematical Theory of Tone Systems, Ján Haluš ka, Marcel Dekker, 2004 The Math Behind the Music, Leon Harkleroad, Cambridge University Press, 2006 Music: A Mathematical Offering, David J. Benson, Cambridge University Press, 2007 From Music to Mathematics, Gareth E. Roberts, Johns Hopkins University Press, 2016 Cool Math for Hot Music: A First Introduction to Mathematics for Music Theorists, Guerino Mazzola, Maria Mannone and Yan Pang, Springer, 2016 Tonal Harmony: With an Introduction to Post-Tonal Music, Stefan Kostka, Dorothy Payne and Byron Almén, McGraw-Hill, 8th edition, 2017	