Tutorial No 2, Semester 2, 2024/25

1. You place your finger 18 cm from one end of a vibrating string which is 72 cm long and the string vibrates at a frequency of 540 Hz. Calculate the fundamental frequency of the string. If the string's length is increased by 25%, what is the distance your finger should be placed from the nearer end of the string so that the string will vibrate with a frequency of 648 Hz?

2. A string 80 cm long vibrates at a frequency of 1,200 Hz with 8 antinodes between its two ends. A second string vibrates at a frequency of 1,500 Hz with 5 antinodes between its two ends. What is the length of the second string? If a third string of length 60 cm vibrates at a frequency of 800 Hz, what is the number of nodes which this third string has between its two ends (not counting the nodes at both ends)? (Assume that the three strings are similar in all respects except for length.)

3. We start from a first musical note and then go up by the interval of a Just sixth to arrive at a second note. We start again from the same first note and go up again, but this time by the interval of a Pythagorean sixth to arrive at a third note. Which of these two notes i.e. the second and third notes, has the higher frequency, and what is the ratio of the interval between these two notes? If the frequency

of the first note is 150 Hz, calculate the frequencies of the second and third notes. If we go down instead of up from 150 Hz by the same two intervals i.e. the Just sixth and the Pythagorean sixth, calculate the frequencies of the second and third notes.

4. The common pentatonic scale on a piano keyboard often used in the folk songs of many musical cultures can be found by playing only the black notes on the keyboard in sequence. This scale is called "pentatonic" which means "five notes" because it consists of only five notes (not counting the note one octave above the beginning of the scale). The common pentatonic scale has the following sequence of intervals: tone, tone, three semitones, tone, three semitones, arriving at the final note exactly one octave or 12 semitones above the starting note. Another type of pentatonic scale is the Balinese gamelan pentatonic scale which has a different sequence of intervals: semitone, tone, 2 tones, semitone, 2 tones, making up a total of 12 semitones. Starting from the note D just above Middle C, give the letter names of the notes making up these two different pentatonic scales. Starting instead from the G just below Middle C, give the names of the notes making up these two pentatonic scales.

5. The strings of a viola are tuned in Just fifths as is usual for a viola, and the viola's A string is tuned to a frequency of 440 Hz. A guitar's six strings are tuned relative to each other as is usual for a guitar, and its A string is tuned to a frequency of 110 Hz. What

are the frequencies of the viola's G string and its D string and the ratio of the interval between these two frequencies? What are the frequencies of the two musical notes on the guitar which are equivalent to these two notes on the viola, and what is the ratio between these two notes on the guitar? Calculate the ratio of the interval between the frequencies of the guitar's B3 note and the viola's D4 note. (Take the ratio of an Equal-tempered semitone to be equal to 1.05946 for your calculations.)

6. The frequency spectrum of a musical note is represented by a graph with vertical lines along the x-axis. The positions of the lines on the x-axis represent the frequencies of the harmonics and the lengths of the lines represent the amplitudes of the harmonics. A musical wind instrument recently unearthed by archeologists is made to play a note which has a spectrum showing its fundamental frequency and all its harmonics up to the 21st harmonic. All harmonics (odd and even) are present in this spectrum. The 8th line from the left in this spectrum has the same frequency as the 7th line from the left in the spectrum of a square wave. If the frequency of the 4th line in the spectrum of the square wave is 1,400 Hz, calculate the frequencies of the 9th and 12th lines from the left in the spectrum of the musical instrument's note.

Scientific Inquiry discussion points

1. The Pythagorean scale, said to be first defined by the Greek mathematician after whom it is named, was based

on the ratios of just two intervals -the octave (2/1) and the fifth (3/2). Its simplicity of construction served as the basis of the music of civilisations such as ancient Greece and China. The Pythagorean scale's drawback was that the ratio of the third was complex (81/64) and deemed unsatisfactory by many. As the interval of the third became more important, proponents of the Just scale, in which the ratio of the third was 5/4 instead of 81/64, much preferred it to the Pythagorean scale, as ratios with small numbers were considered by the Greeks to be more beautiful than ratios with large numbers. The proponents of the Pythagorean scale of course disagreed strongly. Here we see the objective scientific inquiry of Pythagoras coming into conflict with subjective aesthetic judgement. Can you think of other examples in which subjective judgements come into conflict with objective scientific inquiry?