Answers to Tutorial No 1, Semester 2, 2023/24

1. A coconut tree and a tembusu tree which are next to each other are swaying repeatedly from left to right during a strong wind. The coconut tree completes 6 cycles during the same period of time during which the tembusu tree completes 5 cycles. If the tembusu tree completes 8 full cycles in 5 seconds, calculate the frequencies of vibration for each of these two trees. When the wind gets weaker, the frequency of the tembusu tree decreases to 1.2 Hz, and the frequency of the coconut tree decreases by the same proportion. What is the frequency of the coconut tree when the wind gets weaker?
   Answer: Since the tembusu tree completes 8 cycles in 5 seconds, in one second it will complete $\frac{8}{5}$ or 1.6 cycles, and hence its frequency is 1.6 Hz. To complete 5 cycles, the time needed by the tembusu tree is given by 5 cycles divided by 1.6 Hz i.e. 3.125 seconds. The coconut tree will thus complete 6 cycles during this time, so its frequency is equal to 6 cycles divided by 3.125 seconds i.e. 1.92 Hz. The frequency of the tembusu tree decreases from 1.6 Hz to 1.2 Hz when the storm gets weaker, and hence the frequency of the coconut tree will be equal to $\frac{1.2}{1.6}$ times 1.92 Hz i.e. 1.44 Hz.

2. A woman in a shopping mall sings a note with a frequency of 1,320 Hz. If a bass singer passing by

then sings a note which is 4 octaves below the note from the woman, what is the frequency of the bass singer's note? A flute player nearby then plays a note on his flute which has a frequency of 2,640 Hz. Calculate the number of octaves between the flute's note and the woman's note. A bassoon player standing nearby then plays a note on his bassoon which is 3 octaves below the flute's note. Calculate the number of octaves this note is above the bass singer's note and its frequency. If the woman's note is 880 Hz instead of 1,320 Hz, calculate the frequencies of the bass singer's note, the flute's note and the bassoon's note, assuming that these notes maintain the same relationships to each other as before.

Answer: The frequency of the starting note is halved if we move down by an octave, so if the bass singer's note is 4 octaves below 1,320 Hz, its frequency is equal to 1,320 Hz divided by 2 four times, which gives a frequency of 82.5 Hz. The flute's note has a frequency of 2,640 Hz, and since multiplying 82.5 Hz by 2 five times gives 2,640 Hz, 2,640 Hz must be 5 octaves above the bass singer's note and one octave above the woman's note. Since the bassoon's note is 3 octaves below the flute's note, its frequency is given by 2,640 Hz divided by 2 three times i.e. 330 Hz which is two octaves above the bass singer's note. If the woman's note had been 880 Hz instead of 1,320 Hz, the bass singer's note would be equal to 880 Hz divided by 2 four times i.e. 55 Hz. Since the flute's note is five octaves above the bass singer's note it would be equal to 55 Hz times 2 five times i.e. 1,760

Hz. The bassoon's note is 3 octaves below the flute's note, so its frequency is equal to 1,760 Hz divided by 2 three times i.e. 440 Hz.

3. A jazz band is the first item in a campus concert and you notice that it registers 87 dB on a sound level meter which you as a member of the audience are carrying. The next group to perform is a harmonica quartet whose sound reaching you is 100 times less powerful compared with that from the jazz band. What would the reading on your sound level meter be due to the harmonica quartet? The third group performing is a rock band which registers a reading of 97 dB on your sound level meter. How much more sound power is reaching you from the rock band compared to the harmonica quartet? (Assume that the reading on the sound level meter is due only to the sound of the jazz band, the harmonica quartet and the rock band.)
   Answer: Since a decrease of 10 dB of the sound level meter reading indicates a decrease in sound power of 10 times, a decrease of 100 times i.e. 10 times 10 times less sound power should result in a decrease of 10 dB plus 10 dB i.e. 20 dB in the reading. Hence the reading on the sound level meter due to the harmonica quartet should be 87 dB minus 20 dB i.e. 67 dB. The reading due to the rock band of 97 dB is 30 dB i.e. 10 dB plus 10 dB plus 10 dB greater than that due to the harmonica quartet. So the power from the rock band must be 10 times 10 times 10 times i.e. 1,000 times greater than that from the

harmonica quartet.

4. The musical score of a piece for solo voice begins with a time signature of 17/8. One particular bar in this score begins with two crotchets and ends with three dotted quavers. Calculate the number of semiquaver notes which could fit exactly into the middle of this bar in order to correspond exactly with the time signature. If the beginning of the bar had three crotchets instead of two crotchets, how many semiquavers which would fit exactly into the middle of the bar? (If we add a dot to a note or a rest, the duration of the note or rest is increased by 50%.)
   Answer: The time signature is 17/8, so each bar of the piece should have the duration equivalent of 17 quavers or 34 semiquavers. Since the beginning of the bar has two crotchets (which is equivalent to 8 semiquavers), and the end of the bar has three dotted quavers (equivalent to 9 semiquavers), the bar already has a total of 17 semiquavers, and therefore the middle of the bar should be filled with another 17 semiquavers. If the start of the bar had three crotchets (equivalent to 12 semiquavers) instead of two crotchets, the middle of the bar would need another 13 semiquavers.

5. Starting from any key on a piano keyboard and going up or down to a key which is its immediate neighbour, is always a move by the interval of a semitone. Starting from any key to the next key above or below which has the same letter name (i.e. A, B, C, etc), that interval moved is always by 12 semitones

or one octave. If we start from the piano key with the letter name of G just below Middle C, how many semitones are there from this G to the A which is just above Middle C? Express this interval in terms of octaves. Give the letter name of the piano key which is the same number of semitones below the starting G. What is the number of octaves from this lower note to the A just above Middle C?
Answer: If we start from the G just below Middle C and move up to the A just above Middle C, we would have moved by an interval of 14 semitones, which is equivalent to one and one-sixth of an octave. Going down from the starting G by 14 semitones, we will reach the note F which is seven semitones below the C one octave below Middle C. Therefore there is a total of 28 semitones, or two and one-third octaves, from this low F to the A just above middle C.

6. We define the ratio of a musical interval from one musical note to another musical note at a higher pitch as the ratio of the frequency of the higher note to the frequency of the lower note. If we start from a note with a frequency of 80 Hz and move up by an interval with a ratio of $\frac{11}{4}$, what is the frequency of the higher note on which we will arrive? Starting from this second note and going down by an interval with a ratio of $\frac{8}{5}$, what is the frequency of the third note on which we will arrive? Calculate the ratio of the interval between the first note and the third note.
Answer: Since the first note has a frequency of 80 Hz, going up by an interval with a ratio of $\frac{11}{4}$ means

that we should multiply 80 Hz by $\frac{11}{4}$. This gives 220 Hz as the frequency of the second note. If we go down by an interval with a ratio of $\frac{8}{5}$, the frequency of the third note is obtained by dividing 220 Hz by $\frac{8}{5}$, which is the same as multiplying 220 Hz by a ratio of $\frac{5}{8}$, giving a frequency of 137.5 Hz for the third note. We can obtain the ratio of the interval from the first note to the third note by multiplying $\frac{11}{4}$ by $\frac{5}{8}$, giving a ratio of $\frac{55}{32}$. We can also obtain this ratio by dividing the frequency of the third note by the frequency of the first note, giving a ratio of $\frac{137.5}{80}$ which can be simplified to $\frac{55}{32}$.

Scientific Inquiry discussion points

1. Science seeks to discover and understand the universe through the methodology of scientific inquiry. Scientists observe the universe and formulate hypotheses to explain what they observe. They test their hypotheses through experiments and further observation. A hypothesis becomes an accepted theory if supported strongly by experimental or observational evidence. Can you think of examples of scientific inquiry which changed our perception and understanding of the universe?

   There are many examples of scientific inquiry which changed our perception and understanding of the universe. One of the most important was the hypothesis that the earth revolves around the sun and not vice versa. Johannes Kepler was the first scientist to work out the physics of how the earth went around the sun. A more modern example is Albert Einstein's prediction *in his general theory of relativity that light could be bent by gravitational force. The British astronomer Arthur Eddington actually observed such a bending of light when he led an expedition to observe the 1919 solar eclipse in Brazil. They actually observed light from distant stars being deflected by the sun during the solar eclipse.*

2. Technology seeks to shape and modify the universe in order to improve the quality of life in human society. Technology can include simple objects like chairs and lamps, and complex objects like computers and integrated circuits. Like science, technology dates back to the earliest days of mankind, and technological tools and artefacts can be found in the earliest archeological sites. What are good examples of technological achievements in early societies and in modern civilisation?

   Perhaps the most important example of a technological advance in ancient times was the invention of the wheel. How and when this happened is lost in the mists of time, but the wheel very likely came about independently in different civilisations. In more recent times, a significant technological innovation was the telegraph, which made almost instantaneous communications possible. An equally important innovation was the steam engine, which gave society immensely greater motive power beyond human and animal muscle strength and was unaffected by the vagaries of wind and water power.