Answers to Tutorial No 1, Semester 2, 2024/25

1. Two trees next to each other are swaying repeatedly left to right during a strong wind. The shorter tree, a mango tree, completes 12 cycles during the same period of time during which the taller tree, a coconut tree, completes 9 cycles. If the coconut tree completes 6 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 coconut tree decreases to 1 Hz, and the frequency of the mango tree decreases by the same proportion. What is the frequency of the mango tree when the wind gets weaker?
   Answer: Since the coconut tree completes 6 cycles in 5 seconds, it will complete $\frac{6}{5}$ or 1.2 cycles in one second. Therefore its frequency is 1.2 Hz. The coconut tree will complete 9 cycles in a time given by 9 cycles divided by 1.2 Hz i.e. 7.5 seconds. The mango tree will complete 12 cycles during this time so its frequency is equal to 12 cycles divided by 7.5 seconds i.e. 1.6 Hz. The frequency of the coconut tree decreases from 1.2 Hz to 1 Hz when the wind gets weaker, so the frequency of the mango tree will decrease by the same proportion and will be equal to $\frac{1}{1.2}$ times 1.6 Hz i.e. $\frac{4}{3}$ Hz or approximately 1.333 Hz.

2. A little boy strolling in a park sings a note with a

frequency of 1,024 Hz. If a bassoon player relaxing nearby in the park then plays a note which is 4 octaves below the note from the little boy, what is the frequency of the bassoon's note? A flute player standing nearby then plays a note on her flute which has a frequency of 512 Hz. What is the number of octaves between the flute's note and the bassoon's note? A bass singer not too far away then sings a note which is 2 octaves below the flute's note. What is its frequency and the number of octaves this note is above the bassoon's note? If the frequency of the boy's note is 1,760 Hz instead of 1,024 Hz, what would be the frequencies of the bassoon's note, the flute's note and the bass singer's note, if these notes maintained the same frequency relationships to each other as before?

Answer: The frequency of the boy's note is halved if we move down by an octave, so as the bassoon's note is 4 octaves below 1,024 Hz, its frequency is equal to 1,024 Hz divided by 2 four times. This gives a frequency of 64 Hz, and since the flute's note has a frequency of 512 Hz, and multiplying 64 Hz by 2 three times gives 512 Hz, 512 Hz must be 3 octaves above the bassoon's note. The bass singer's note is 2 octaves below the flute's note so its frequency is given by 512 Hz divided by 2 two times i.e. 128 Hz which is one octave above the bassoon's note. If the boy's note had been 1,760 Hz instead of 1,024 Hz, the bassoon's note would be equal to 1,760 Hz divided by 2 four times i.e. 110 Hz, and since the flute's note is three octaves above the bassoon's note it would be equal to 110 Hz times 2 three times i.e. 880 Hz. The bass singer's note is 2 octaves below the flute's note, so its frequency would be given by 880 Hz divided by 2 two times i.e. 220 Hz.

3. The siren of a fire engine passing right in front of you registers a sound level of 98 dB on a sound level meter you are carrying. When the fire engine stops at a house on fire some distance away, the sound from its siren is 100 times weaker than when it was in front of you. What would the reading be on your sound level meter due to the siren? After the fire engine turns off its siren, the siren of a police car at the location of the fire registers a reading of 68 dB on your sound level meter. How much less or more powerful is the sound from the police car's siren compared to the siren of the fire engine? (Assume that the reading on the sound level meter is due only to the sound of the fire engine's siren or the police car's siren.)

   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 less sound power should result in a decrease of 10 dB plus 10 dB i.e. 20 dB in the sound level meter reading. Therefore the reading on the sound level meter due to the fire engine's siren at the fire should be 98 dB minus 20 dB i.e. 78 dB. Since the reading due to the police car's siren is 68 dB i.e. 10 dB less than that due to the fire engine's siren, the power from the police car's siren must be 10 times less than that from the fire engine's siren.

4. A sonata for solo flute starts with a time signature of 28/8. A certain bar in this sonata begins with four dotted quavers and ends with a minim. How many semiquaver notes could fit into the middle of this bar in order to correspond exactly with the time signature? If the end of the bar had two dotted crotchets instead of one minim, how many semiquavers would then 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 28/8 which means that each bar of the piece must have the duration equivalent of 28 quavers or 56 semiquavers. Since the beginning of the bar already has four dotted quavers (which are equivalent to 12 semiquavers), and the end of the bar has a minim (equivalent to 8 semiquavers), the bar already has a total of 20 semiquavers, and thus the middle of the bar should be filled with another 36 semiquavers. If the end of the bar had two dotted crotchets (equivalent to 12 semiquavers) instead of a minim, the middle of the bar would need another 32 semiquavers.

5. Starting from any key on a piano keyboard and going up or down to a key which is its immediate neighbour, the interval moved is always 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), the interval moved is always 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, and what is this interval in terms of octaves? What is the letter name of the piano key which is the same number of semitones below the starting G? Give the number of octaves from this lower note to the A just above Middle C.
Answer: Starting from the G just below Middle C and moving 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. If we go 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 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 256 Hz and move up by an interval with a ratio of $\frac{13}{8}$, calculate 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 $\frac{16}{11}$, calculate the frequency of the third note on which we will arrive. What is the ratio of the interval between the first note and the third note?
Answer: Since the first note has a frequency of 256 Hz, going up by an interval with a ratio of $\frac{13}{8}$ means

multiplying 256 Hz by $\frac{13}{8}$, which gives 416 Hz as the frequency of the second note. If we go down by an interval with a ratio of $\frac{16}{11}$, the frequency of the third note is obtained by dividing 416 Hz by $\frac{16}{11}$, which is the same as multiplying 416 Hz by an interval of $\frac{11}{16}$, giving a frequency of 286 Hz for the third note. We can obtain the ratio of the interval from the first note to the third note by multiplying $\frac{13}{8}$ by $\frac{11}{16}$, which gives a ratio of $\frac{143}{128}$. We can also obtain the same ratio by dividing the frequency of the third note by the frequency of the first note, giving a ratio of $\frac{286}{256}$ which can be simplified to $\frac{143}{128}$.

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.