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

1. Two flagpoles of different lengths are next to each other and are swaying repeatedly back and forth during a storm. The shorter flagpole completes 9 cycles during the same period of time during which the longer flagpole completes 6 cycles. If the longer flagpole completes 8 full cycles in 5 seconds, what are the frequencies of vibration for each of these two flagpoles? When the storm gets stronger, the frequency of the longer flagpole increases to 2.8 Hz, and the frequency of the shorter flagpole increases by the same proportion. Calculate the frequency of the shorter flagpole when the storm gets stronger.
   Answer: The longer flagpole completes 8 cycles in 5 seconds, so in one second it will complete $\frac{8}{5}$ or 1.6 cycles so its frequency is 1.6 Hz. The time needed by the longer flagpole to complete 6 cycles is equal to 6 cycles divided by 1.6 Hz i.e. $\frac{15}{4}$ seconds. Since the shorter flagpole will complete 9 cycles during this time, its frequency is given by 9 cycles divided by $\frac{15}{4}$ seconds i.e. 2.4 Hz. The frequency of the longer flagpole increases from 1.6 Hz to 2.8 Hz when the storm gets stronger, so the frequency of the shorter flagpole will be given by $\frac{2.8}{1.6}$ times 2.4 Hz i.e. 4.2 Hz.

2. A young girl walking in a park sings a note with a frequency of 1,760 Hz. A tuba player who is passing by then plays a note which is 5 octaves below the

note from the girl. Calculate the frequency of the tuba's note. If a clarinet player walking nearby then plays a note on her clarinet which has a frequency of 220 Hz, what is the number of octaves between the clarinet's note and the tuba's note? If a singer waiting not far away then sings a note which is 2 octaves above the clarinet's note, what is its frequency and the number of octaves this note is above the tuba's note? If the girl's note is 1,320 Hz instead of 1,760 Hz, calculate the frequencies of the tuba's note, the clarinet's note and the singer's note, assuming that these notes maintain the same relationships to each other as before.

Answer: Since the frequency of the starting note is halved if we move down by an octave, if the tuba's note is 5 octaves below 1,760 Hz, its frequency is given by 1,760 Hz divided by 2 five times, giving a frequency of 55 Hz. The clarinet's note has a frequency of 220 Hz, and since multiplying 55 Hz by 2 two times gives 220 Hz, 220 Hz must be 2 octaves above the tuba's note. Since the singer's note is 2 octaves above the clarinet's note, its frequency is given by 220 Hz multiplied by 2 two times i.e. 880 Hz which is 4 octaves above the tuba's note. If the girl's note had been 1,320 Hz instead of 1,760 Hz, the tuba's note would be equal to 1,320 Hz divided by 2 five times i.e. 41.25 Hz. Since the clarinet's note is 2 octaves above the tuba's note it would be equal to 41.25 Hz times 2 two times i.e. 165 Hz. The singer's note is 2 octaves above the clarinet's note, so its frequency would be equal to 165 Hz multiplied by 2 two times i.e. 660 Hz.

3. A brass band's performance is the first item in a community centre concert which you attended. You notice that it registers 94 dB on a sound level meter which you are carrying. The next group to perform is a children's choir made up of very young boys and girls. If the sound reaching you from the choir is 1,000 times less powerful compared to that from the brass band, what would the reading on your sound level meter be due to the choir? A string quartet which is the third group performing registers a reading of 74 dB on your sound level meter. Calculate how much less sound power is reaching you from the string quartet compared to the brass band. (Assume that the reading on the sound level meter is due only to the sound of the brass band, the children's choir and the string quartet.)
   Answer: A decrease of 10 dB of the sound level meter reading indicates a decrease in sound power of 10 times, so a decrease of 1,000 times i.e. 10 times 10 times 10 less sound power should result in a decrease of 10 dB plus 10 dB plus 10 dB i.e. 30 dB in the reading. Therefore the reading on the sound level meter due to the children's choir should be 94 dB minus 30 dB i.e. 64 dB. Since the reading due to the string quartet is 74 dB i.e. 20 dB or 10 dB plus 10 dB less than that due to the brass band, the power from the string quartet must be 10 times 10 i.e. 100 times less than that from the brass band.

4. A piece for solo violin begins with a time signature

of 23/8, and one particular bar in this score begins with three quavers and ends with a dotted crotchet. What is 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 end of the bar had four crotchets instead of one dotted crotchet, 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: Since the time signature is 23/8, each bar of the piece should have the duration equivalent of 23 quavers or 46 semiquavers. The beginning of the bar already has three quavers (which is equivalent to 6 semiquavers), and the end of the bar has a dotted crotchet (equivalent to 6 semiquavers), so the bar already has a total of 12 semiquavers. Hence the middle of the bar should be filled with another 34 semiquavers. If the end of the bar had four crotchets (equivalent to 16 semiquavers) instead of a crotchet, the middle of the bar would need another 24 semiquavers.

5. If we were to start from any key on a piano keyboard and go up or down to a key which is its immediate neighbour, this move is always by the interval of a semitone. If we start 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. Starting from the piano key with the letter name of A just above Middle C,

how many semitones are there from this A to the B which is just below Middle C? What is this interval in terms of octaves? Find out the letter name of the piano key which is the same number of semitones above the starting A. What is the number of octaves from this higher note to the B just below Middle C?
Answer: Starting from the A just above Middle C and moving down to the B just below Middle C, we would have moved by an interval of 10 semitones, which is equivalent to five-sixths of an octave. Going up from the starting A by 10 semitones, we will reach the note G which is seven semitones above the C one octave above Middle C. Therefore there is a total of 20 semitones, or one and two-thirds octaves, from this high G to the B just below middle C.

6. The ratio of a musical interval from one musical note to another musical note at a higher pitch is defined as the ratio of the frequency of the higher note to the frequency of the lower note. Starting from a note with a frequency of 320 Hz and moving down by an interval with a ratio of $\frac{16}{7}$, what is the frequency of the lower note on which we will arrive? Starting from this second note and going up by an interval with a ratio of $\frac{13}{4}$, 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: The first note has a frequency of 320 Hz, so going down by an interval with a ratio of $\frac{16}{7}$ means that we should divide 320 Hz by $\frac{16}{7}$. This is the same as multiplying 320 Hz by an interval of $\frac{7}{16}$ which gives

140 Hz as the frequency of the second note. If we go up by an interval with a ratio of $\frac{13}{4}$, the frequency of the third note is obtained by multiplying 140 Hz by $\frac{13}{4}$, giving a frequency of 455 Hz for the third note. We can obtain the ratio of the interval from the first note to the third note by multiplying $\frac{7}{16}$ by $\frac{13}{4}$, giving a ratio of $\frac{91}{64}$. 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 $\frac{455}{320}$ which can be simplified to $\frac{91}{64}$.

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.