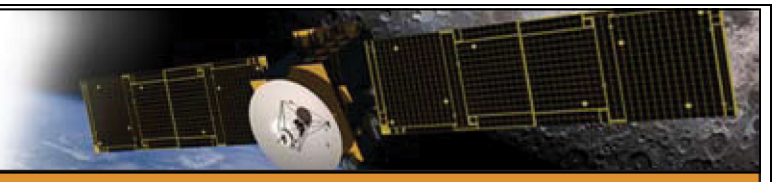


Particles, Waves and Quanta: Set 10

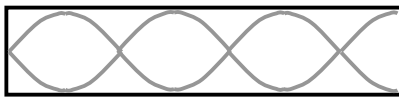
15.

Musical notes								
Note	c	d	e	f	g	a	b	c'
Freq	256	288	320	341	384	427	480	512
Ratio	*11*	*98*	*108*	*43*	*128*	*53*	*158*	*21*

16. a) The **piano** has the greatest range (3873 Hz).
    b) The **bass** singer produces the lowest frequency (80 Hz).
    c) The **piano** can produce the highest pitched note (3900 Hz).
    d) The **Baritone's** range is the most restricted at 300 Hz.

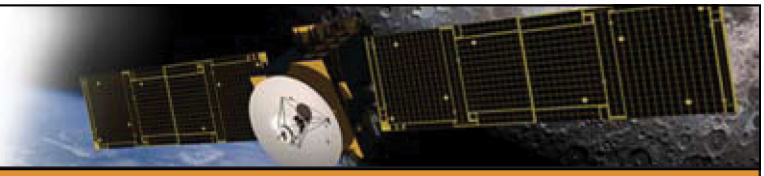
17. a) The left trace shows the loudest note. The vertical scale indicates the wave height is about 3.5 cm high compared with 2.8 cm for the right-hand trace.
    b) Periodic time for the waves is shown by the horizontal scale. The left trace has a period corresponding to 2 squares, whereas with the right-hand trace, one wave occurs in about 1.2 squares. Frequency is inversely proportional to the period so the right-hand trace has a frequency ratio of 2 : 1.2 compare to the left i.e. 1.7 times greater frequency.
    c) The wavelength of a wave is directly proportional to the Period of the wave, so the left-hand wave has the greater wavelength in the ratio 2 : 1.2 to the other wave i.e. a wavelength which is 1.7 times longer.

18. a) The lowest intensity points (pressure nodes) are 0.32 m apart, as shown by the graph. These are ½ of a wavelength apart which means the wavelength is 2 x 0.32 = 0.64 m.
    b) $v = f\lambda = 512 \times 0.64 = 328 \text{ m s}^{-1}$.
    c) The distance between a node and an adjacent antinode equals ¼ of a wavelength. The graph shows seven quarter wavelengths so it represents the 7^{th} harmonic or 1¾ whole waves. Only closed pipes will produce harmonics which are odd multiples of one quarter of a wave. Hence it must be a closed pipe.



19. a) Violins seem to be able to produce the largest range of frequencies.
    b) The trumpet and the double bass both seem to have the most restricted range of frequencies.

20. a) the lowest note would have the longest wavelength. This is produced by the oboe.
    b) The saxophone most likely would be an alto saxophone, looking at its waveform. Higher harmonics produce a sharper, spikier waveform and an alto instrument produces a more treble sound made by a greater number of higher harmonics added to the fundamental note.
    c) The different shaped traces show that there is a wide variation in harmonic content of the different instruments. By adding other harmonics to a basic fundamental note a complex waveform is produced, giving the instrument a unique timbre.
    d) Musical notes display a regular pattern in their waveform and noises display randomness. All the patterns show a repeated pattern and hence must be musical notes.



21. By placing the tuning fork in contact with a larger object this causes the other object to vibrate in sympathy (forced vibration). Because the other object has a larger surface area it can radiate a larger mass of air, which produces a louder sound as more energy is dissipated.

22. The wine glass has its own natural frequency at which it vibrates if struck (e.g. flicked with a finger). Sound waves coming from the singer cause regular air compressions to arrive and hit the glass. If the frequency of these compressions matches the natural frequency of the glass, they cause resonance to occur, where the amplitude of vibration builds up to a point where the glass can shatter.

23. In structures such as bridges, cables and chimneys the effect of winds can be to cause resonance in the structure which can be destructive. By adding mechanical systems that absorb the wind energy (damping) the amplitude of the vibrations can never build up to a destructive resonance level.

24. a) Shape B would show the frequency outline for the Sheath-tail and Free-tail bats as this shows a shallow frequency range.
    b) Shape A displays the largest range of frequencies used
    c) Shape C has the longest timed call and the greatest single frequency range. This would match the Horseshoe and leaf-nosed bat.

25. Rattles in cars at a particular speed are caused by resonance in components of the body (body shell, springs etc.) The forcing frequency usually comes from unbalanced wheels which give regular pulses that can match the natural frequency of the components at a particular rotational frequency.

26. a) 'Dead spots' are areas where sound levels are very soft and are caused by the destructive interference of two sound waves arriving at that area. One wave comes to a point straight from the instrument and the other wave arrives out of phase because it has travelled a greater distance due to reflection off a wall. Because the path difference between these two waves is an odd number of half wavelengths the sound pressure is cancelled at that point.
    b) In concert hall design 2 any sound waves striking the walls is partially absorbed which means that reflection is much less likely to occur and so the 'dead spots' problem is greatly reduced. Hall 2 is therefore the best design.