T6 Solutions

Q1. Briefly describe a wave.

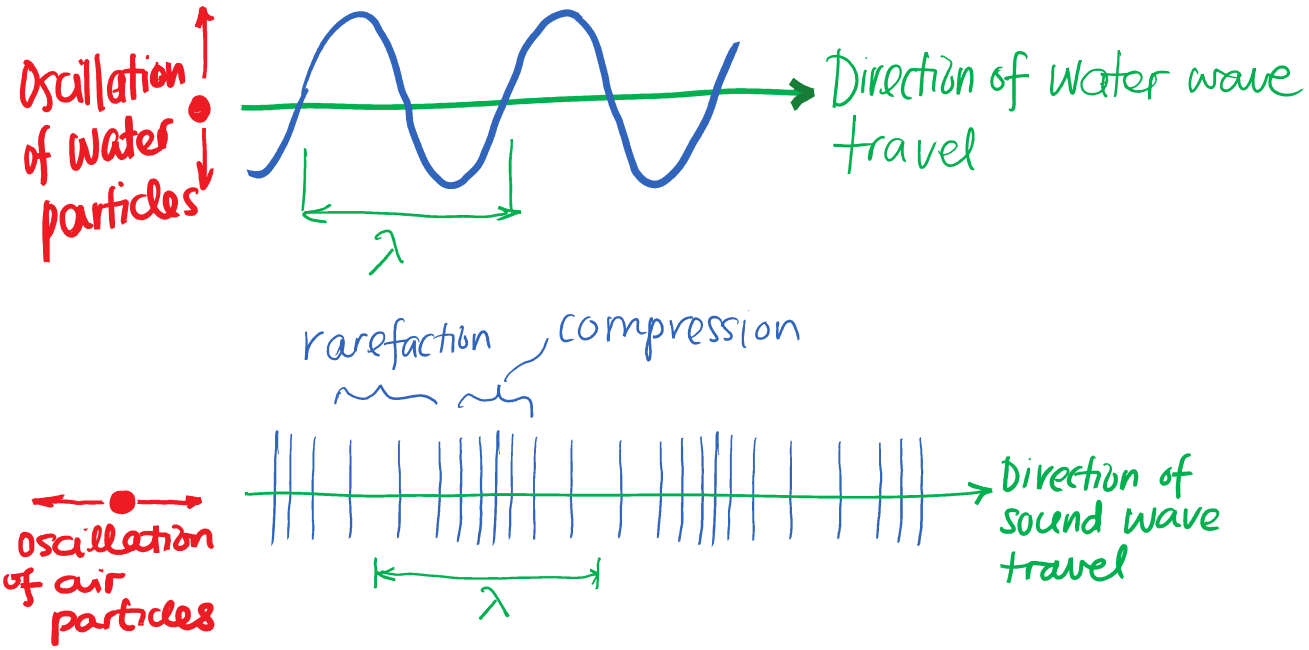
A wave is any disturbance from an equilibrium condition that propagates from one region of space to another without there being any transfer of matter.

Q2. What are the 2 common types of waves? Give an example of each.

Transverse waves *– the particles of the medium oscillate perpendicular to the wave's direction of travel. Example: water waves.*

Longitudinal waves *– the particles of the medium oscillate parallel to the wave's direction of travel. Example: sound waves.*

Q3. Illustrate with drawings how water waves travel and how sound wave travels in air.



Q4. An observer notices a lightning bevent before he hears the accompanying thunder. If he is 5 km from the lightning discharge and the speed of sound in air is 0.34 km/s, calculate the time elapse before he hears the thunder.

$$t = \frac{5\ km}{0.34\ km/s} = 14.7\ s$$

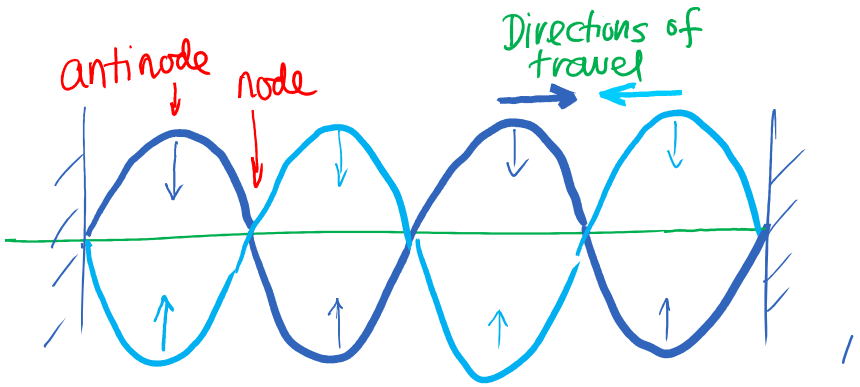
Q5. Determine the wavelength of a 300 Hz wave given that it is propagating at 1.8 km/s.

$$v = f\lambda \Rightarrow \lambda = \frac{1.8\times10^{3}\ m/s}{300/s} = 6\ m$$

v: 1.8 km/s, f: 300 Hz

Q6. Describe standing wave.

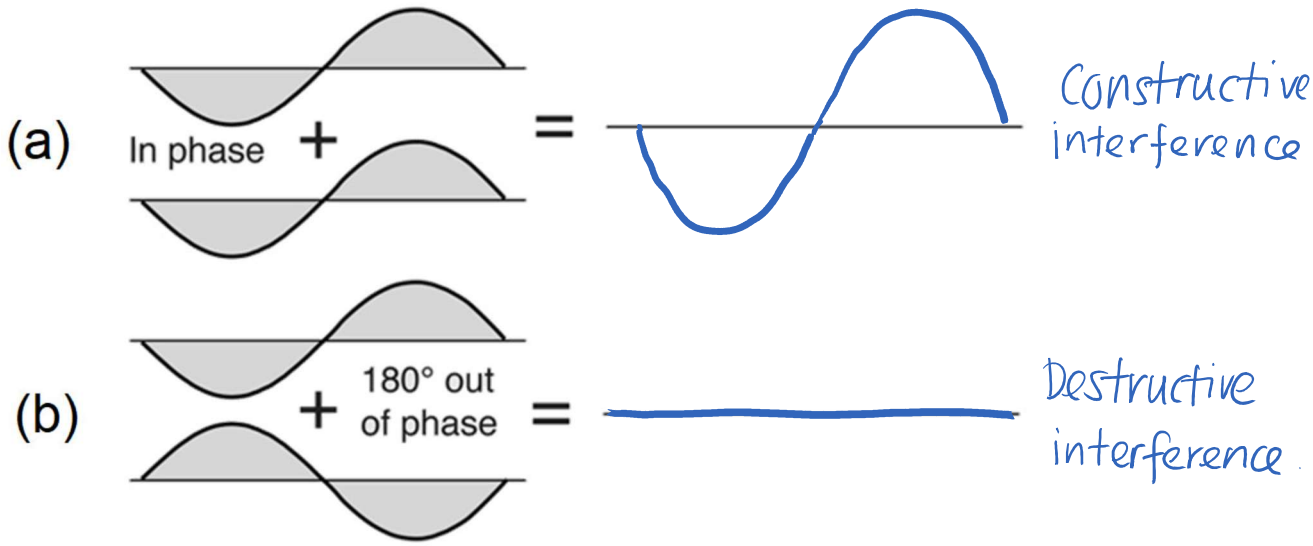
If 2 sinusoidal waves of the same amplitude and wavelength travel in opposite directions along a stretched string, they interfere with each other to produce a standing wave. This is illustrated in the following diagram. At the nodes, there is no displacement. At the antinodes, the string oscillates (up and down in this situation).



Q7. Draw the nodes and antinodes of a standing wave.

Nodes and antinodes are indicated in the diagram for answer to question 6.

Q8.



Q9. List the properties of sound.

Sound propagates as a longitudinal wave which creates alternating compressions and rarefactions of particles in the medium in which it travels.

Sound propagates at a higher velocity in denser medium.

(Refer to module notes if you are interested to find out more about sound.)

Q10. Calculate the sound level in decibels (dB) if the intensity of sound is 10^{-5} W/m^2.

No need to memorise formula

$\beta(dB) = 10\log_{10}\frac{I}{I_0}$ ← $I = 10^{-5}$ W/m²

$= 10\log_{10}\frac{10^{-5}}{10^{-12}} = 10\log_{10}10^{7} = 70dB$

$I_0 = 10^{-12}$ W/m² (a very faint sound intensity)

Q11. Give the relationships of velocity of sound and the Young's modulus, the Bulk modulus and the density of the medium (solid, liquid, gas) in which it is propagating.

No need to memorise these 2 formulae

$v = \sqrt{\frac{B}{\rho}}$ ← Bulk modulus; ← density of gas/liquid

$v = \sqrt{\frac{Y}{\rho}}$ ← Young's modulus; ← density of solid

Q12. Compute the speed of sound in a metal rod given that the Young's modulus and the density of the rod are Y = 7.25 x 10^6 N/m^2 and ρ = 2.9 kg/m^3 respectively.

$v = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{7.25\times10^6\,(N/m^2)}{2.9\;(kg/m^3)}} = 1581\,m/s$

Q13. What is the frequency of ultrasound? List the applications of ultrasound.

Ultrasound refers to sound of frequencies above what human can hear, which is normally above 20 kHz.

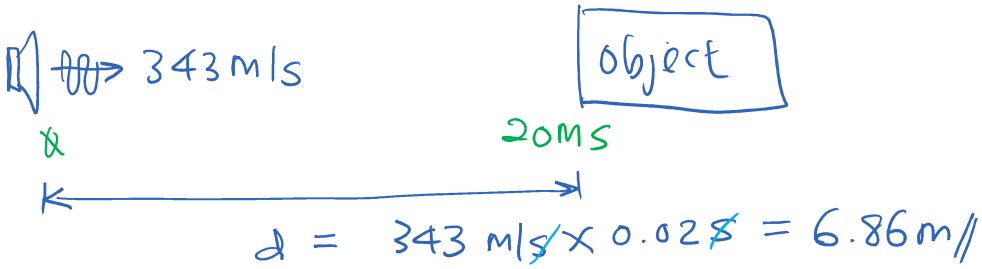
Ultrasound founds applications in medical ultrasound imaging, non-destructive testing of materials, sensors for object/obstacle detection and distance measurement.

And silent dog whistles for training animals which can hear sound of frequencies above what human can hear ☺.

Q14. What does RADAR stands for?

***Ra**dio (waves) **D**etection **a**nd **R**anging*

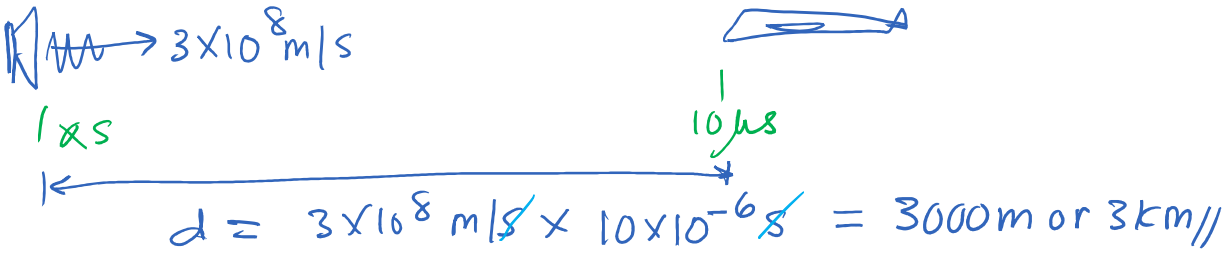
15. An autonomous car is fitted with an ultrasound obstacle detector. Find the distance, d, of the object from an autonomous car if it takes 40 ms for the signal to return after it is being emitted by the detector. Velocity of sound is 343 m/s.



16. With the aid of a diagram, explain Doppler's effect.

Section 6.8.2 of Chapter 6.

17. An airport control station radar picked up a signal from an aircraft 20 µs after emitting the signal. How far is the aircraft from the control station? $c = 3 \times 10^8$ m/s.



(18 – 21 have appeared in tutorial 5.)