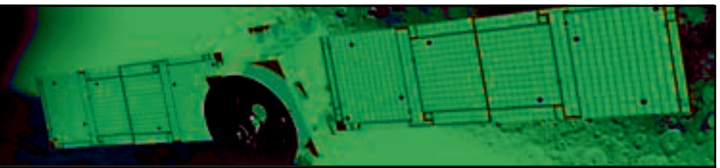
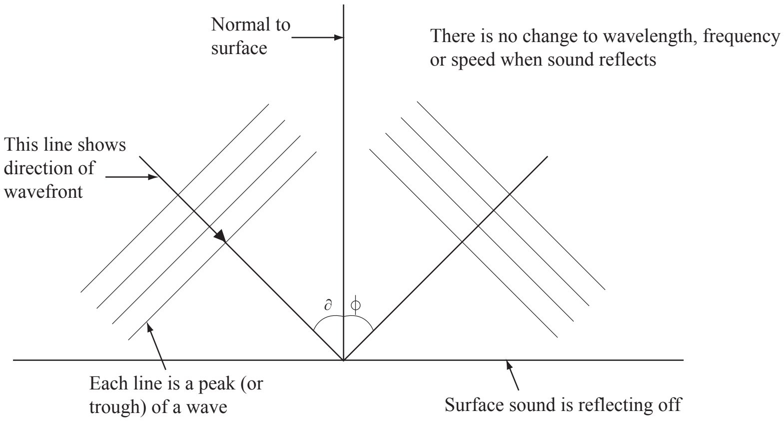


Particles, Waves and Quanta: Set 10

Set	Problem	Solution
10	1a	see below

1a

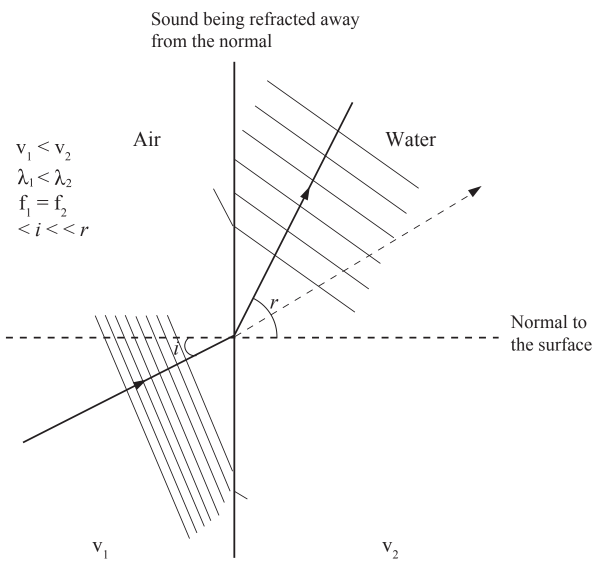


∂ = angle between incident wave and normal

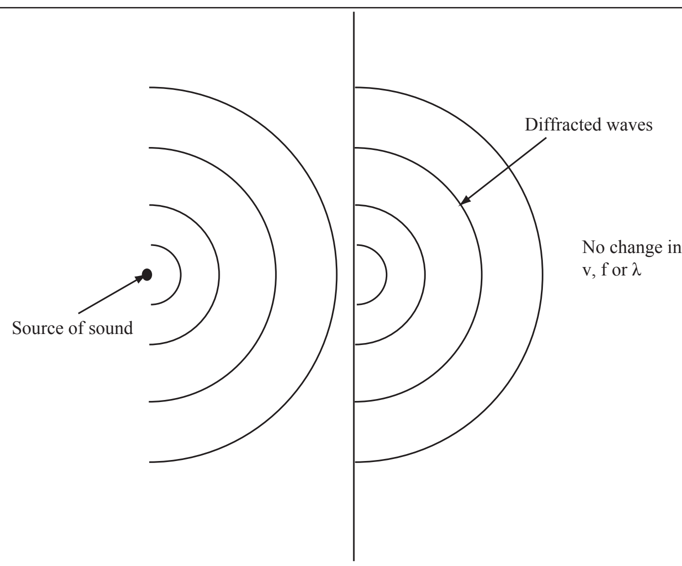
ϕ = angle between reflected wave and normal

∂ = ϕ

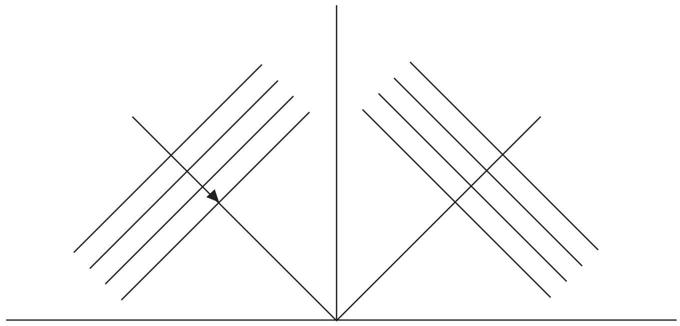
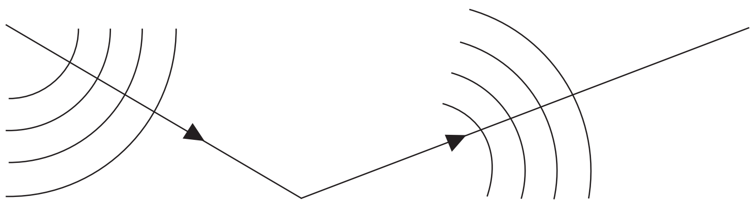
1b



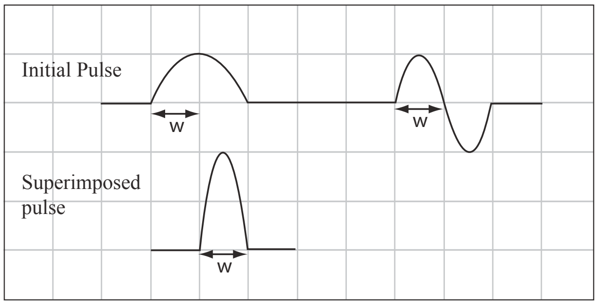
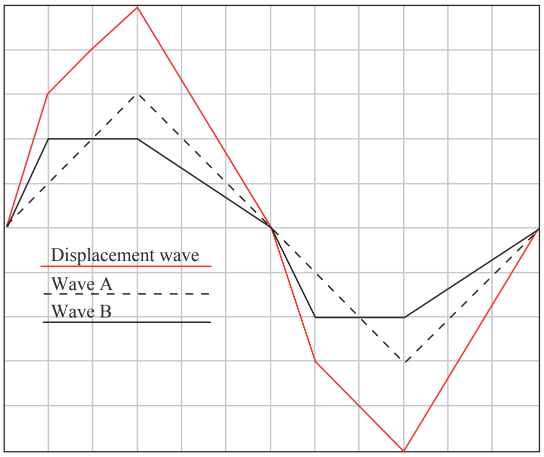
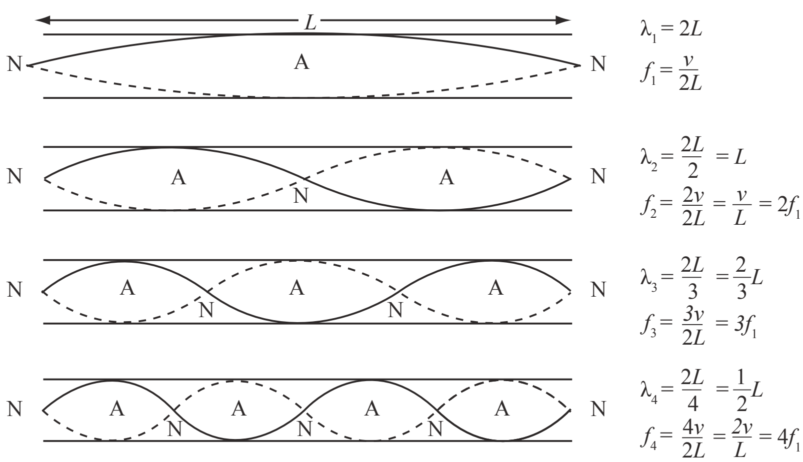
1c

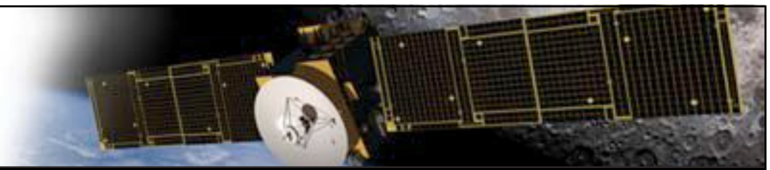


Particles, Waves and Quanta: Set 10

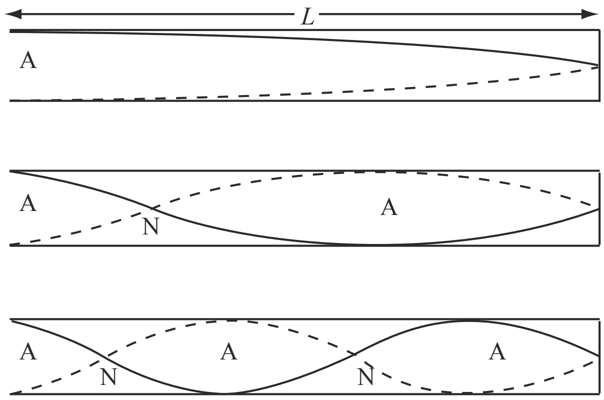
Set	Problem	Solution
10	2a	
	2b	
	3a	It remains unchanged
	3b	It remains unchanged
	3c	$f = \frac{v}{\lambda} = \frac{335\ m\ s^{-1}}{10\ m} = 34\ Hz$ Use same method for λ = 0.02 m, f = 17 kHz
	4	The blind person has learned to use the sounds around them to indicate where obstacles are.
	5a	$\lambda_{air} = \frac{v}{f} = \frac{335\ m\ s^{-1}}{180 \times 10^3\ Hz} = 1.9\ mm$ Similarly v_{water} = 1500 m s^{-1} leads to λ = 8.1 mm in water
	5b	The increased wavelength of ultrasound in water makes it more difficult for the dolphins to resolve fine detail.
	5c	The bats that are flying high and fast need to use a louder signal to ensure that they hear the reflection. Bats flying slowly don't need the reflected sounds to travel over long distances so can use a quieter sound.
	6	0.1 s is time to travel to bottom and back, so time to travel to depth is 0.05 s. speed × time = distance = 1456 m s^{-1} × 0.05 s = 72.8 m
	7a	$number\ of\ pulses = \frac{0.2\ s}{0.002\ s}$ 100
	7b	In 0.1 s there will be 50 pulses. $angle\ between\ pulses = \frac{angle\ of\ scan}{number\ of\ pulses} = \frac{40°}{50}$ Angle between pulses = 0.8°
	7c	$number\ of\ scans = \frac{time}{time\ per\ scan} = \frac{1\ s}{0.1\ s}$ 10 scans in 1 second
	8	A lower frequency has a longer wavelength and are diffracted more so travel over more of the ocean.
	9	The water is getting shallower.

Particles, Waves and Quanta: Set 10

Set	Problem	Solution
10	10	
	11	
	12	708 Hz
	13a	For stringed instruments wavelength of first harmonic $\lambda_1 = 2\times L$, $\lambda_1 = 2 \times 0.5$ m = 1 m $v = f\lambda = 512$ Hz × 1m = 512 m s^{-1}
	13b	The note changes because the length of the vibrating string changes. As the length decreases, the frequency increases, since f? $^1/_L$
	13c	$f_1 = \frac{v}{2L} = \frac{210\ m\ s^{-1}}{2.5\ m} = 84$ Hz $f_2 = 2f_1 = 168$ Hz $f_3 = 3f_1 = 262$ Hz
	14a	



Particles, Waves and Quanta: Set 10

Set	Problem	Solution
10	14b	 $\lambda_1 = 4L$, $f_1 = \frac{v}{4L}$ $\lambda_3 = \frac{4L}{3}$, $f_3 = \frac{3v}{4L} = 3f_1$ $\lambda_5 = \frac{4L}{5}$, $f_5 = \frac{5v}{4L} = 5f_1$
	15	288 Hz, 320 Hz, 341 Hz, 384 Hz, 427 Hz, 480 Hz, 512 Hz (in each case multiply frequency of first harmonic by the ratio)
	16a	Piano
	16b	Bass
	16c	Piano
	16d	Baritone
	17	The signal on the right is showing a sound of single frequency. The instrument on the left produces a sound made of two notes of the same frequency as each other but ½ the frequency of the signal on the right. Where there are 2 frequencies one is louder than the single frequency sound and one is quieter. The signal on the left has a longer wavelength
	18a	λ = twice the distance between troughs