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Exercises and Complements for the Introduction to Physics I for Students of Biology, Pharmacy and Geoscience

Sheet 11 / November 7, 2017 **Solutions**

Exercise 44.
From the constraint for a standing wave you can calculate the wave length of the fundamental tone $\lambda = 2l = 2$ m. Therefore the velocity of the propagation is:

$$v = \lambda f = 880 \text{ m/s}$$

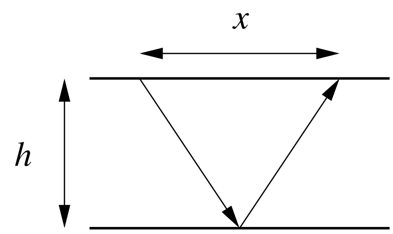
Exercise 45.
(a) We test both cases:
For a pipe open at both ends the equation for the frequency of a successive harmonic series is $f_n = (n+1)f_0$ with $n = 0, 1, 2, 3, ...$ Therefore the difference between the successive frequencies is $f_0 = (1834 - 1310) = (2358 - 1834) = 524$ Hz. From this and the previous equation we calculate n for 1310 Hz and we obtain $n = 1310/524 - 1 = 1.5$. This value is not allowed, since n has to be an integer. If the pipe is closed at one end, the frequency is defined by $f_n = (2n+1)f_0$ with $n = 0, 1, 2, 3, ...$ Therefore the difference between the successive frequencies is $2f_0 = 524$ Hz and $f_0 = 262$ Hz. The three frequencies correspond to $n = 2, 3, 4$
(b)

$$f_0 = 262 \text{ Hz}$$

(c)

$$L = \frac{v_{Schall}}{4f_0} = 0.324 \text{ m}$$

Exercise 46.
Path of the impulse (see figure):



$$s = 2\sqrt{\left(\frac{x}{2}\right)^2 + h^2} = ct$$

From this it follows that:

$$4\frac{x^2}{4} + 4h^2 = c^2t^2$$

$$h = \frac{1}{2}\sqrt{c^2t^2 - x^2} = 45.8 \text{ m}$$

Exercise 47.
The logarithmic scale of the sound power intensity is defined by (Script 109-24):

$$L = 10 \cdot \log_{10} I/I_0 = 10 \cdot \lg I/I_0$$

We assume that the thunder whistles are blown more or less the same way and produce therefore the same amount of noise. If thunder whistles would produce a pure tone we would have to consider constructive and destructive interference. Then the total sound power density could be for example smaller. According to the previous equation, the intensity for two whistles is:

$$L_2 = 10 \cdot \lg \frac{I_1 + I_2}{I_0} = 10 \cdot \lg \frac{2I}{I_0}$$

and for n whistles it is:

$$L_n = 10 \cdot \lg \frac{nI}{I_0}$$

the difference :

$$L_n - L = 10 \left(\lg \frac{nI}{I_0} - \lg \frac{I}{I_0} \right) = 10 \cdot \lg n$$

from this it follows:

$$10 \lg n > 10 \text{ dB} \Rightarrow n > 10$$

Additional Exercise Script 109-17:

$$B(t, x) = A_0 \cos(\omega t - kx + \varphi)$$

x_1:

$$\begin{aligned} 0 &= B(t, x) + A(t, x) \\ 0 &= A_0[\cos(\omega t - kx_1 + \varphi) + cos(\omega t + kx_1 + \varphi_A)] \end{aligned}$$

or

$$\cos(\omega t - kx_1 + \varphi) = -\cos(\omega t + kx_1 + \varphi_A) = \cos(\omega t + kx_1 + \varphi_A + \pi)$$

$$-kx_1 + \varphi = kx_1 + \varphi_A + \pi$$

$$\varphi = 2kx_1 + \varphi_A + \pi = 538^\circ (\text{mod } 360^\circ) = 178^\circ$$

from this it follows:

$$B(t, x) = A_0 \cos(\omega t - kx + 178^\circ)$$