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

Sheet 11 / 30.11.2020 **Solutions**

Exercise 51.

(a) For a pipe open at both ends the equation for the frequency of a successive harmonic series is

$$f_n = (n+1)f_0 \text{ with } n = 0, 1, 2, 3, ...$$

Therefore the difference between the successive frequencies is:

$$f_0 = (1834 - 1310) = (2358 - 1834) = 524 \text{ Hz}.$$

From this and the previous equation we calculate n for 1310 Hz and we obtain:

$$n = \frac{f_n}{f_0} - 1 = \frac{1310}{524} - 1 = 1.5$$

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:

$$f_n = (2n+1)f_0 \text{ with } n = 0, 1, 2, 3, ...$$

Therefore, the difference between the successive frequencies is $2f_0 = 524$ Hz and $f_0 = 262$ Hz. The three frequencies correspond to $n = 2, 3, 4$.

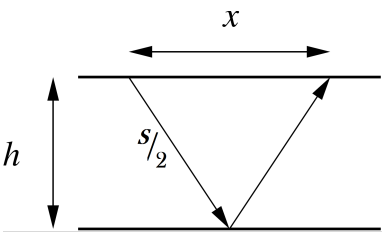
(b)

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

(c)

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

Exercise 52.



The path of the impulse is:

$$s = c \cdot t = 2200 \frac{\text{m}}{\text{s}} \cdot 0.1 \text{ s} = 220 \text{ m}$$

With Pythagoras' law (see figure), it follows:

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

$$h = \sqrt{\left(\frac{s}{2}\right)^2 - \left(\frac{x}{2}\right)^2} = \sqrt{(110 \text{ m})^2 - (100 \text{ m})^2} = 45.8 \text{ m}$$

Exercise 53.

The logarithmic scale of the sound power intensity is defined by ($\log_{10} = \lg$):

$$L = 10 \cdot \lg \frac{I}{I_0}$$

(a) We assume that the thunder whistles are blown in 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 n whistles is:

$$L_n = 10 \text{ dB} \cdot \lg \frac{n \cdot I_1}{I_0}$$

For 10 whistlers we will get:

$$\begin{aligned} L_{10} &= 10 \text{ dB} \cdot \lg \frac{10 I_1}{I_0} \\ &= 10 \text{ dB} \cdot \lg 10 + 10 \text{ dB} \cdot \lg \frac{I_1}{I_0} \\ &= 10 \text{ dB} \cdot \lg 10 + 120 \text{ dB} \\ &= 130 \text{ dB} \end{aligned}$$

(b) The same applies to the drummers:

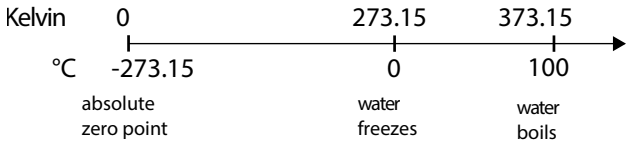
$$\begin{aligned} 10 \text{ dB} \cdot \lg \frac{n \cdot I_1}{I_0} &\geq 130 \text{ dB} \\ 10 \text{ dB} \cdot \lg n + 10 \text{ dB} \cdot \lg \frac{I_1}{I_0} &\geq 130 \text{ dB} \\ 10 \text{ dB} \cdot \lg n + 100 \text{ dB} &\geq 130 \text{ dB} \\ 10 \text{ dB} \cdot \lg n &\geq 30 \text{ dB} \\ \lg n &\geq 3 \\ n &\geq 1000 \end{aligned}$$

So it needs 1000 drummers to get over the pain threshold of 130 dB.

Exercise 54.

(a) A change of temperature by 1 °C corresponds to a change in temperature by 1 K.
From this it follows: 30 °C + 273.15 K $\hat{=}$ 30 K + 273.15 K = 303.15 K

(b)



(c) As mention before, a change of temperature by 1 °C corresponds to a change in temperature by 1 K. Therefore 77 K + 70 K = 147 K.

Exercise 55.

The volume of the mercury expands during warming up on the left side. Because of this, it spreads to the right side towards the attachment. The center of mass of the heated up mercury shifts to the right and therefore also the center of mass of the entire system. Due to this, the left side rises.
By heating up the iron tube on the left side, this end gets elongated. Due to this, the center of mass shifts to the left and therefore the left side sinks.