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

Sheet 10 / November 4, 2019 **Solutions**

Exercise 46.

$$f = \frac{1}{T} = 1 \text{ kHz} \qquad v = \lambda f = 340 \text{ m/s}$$

$$\omega = 2\pi f = 6.28 \cdot 10^3 \text{ s}^{-1} \qquad k = \frac{2\pi}{\lambda} = 18.5 \text{ m}^{-1}$$

Aufgabe 47.

(a) Frequency:

$$f = \frac{\omega}{2\pi} = \frac{1980 \text{ s}^{-1}}{2\pi} = 315.1\,\text{Hz}$$

(b) The wavelength can be calculated from the wave number:

$$k = \frac{2\pi}{\lambda} = 6 \text{ m}^{-1} \Rightarrow \lambda = \frac{2\pi}{k} = 1.05\,\text{m}$$

(c) The phase velocity is:

$$c = \frac{\omega}{k} = \lambda f = 330\,\text{ms}^{-1}$$

(d) For a harmonic wave the observed position x is irrelevant. Simplifying and setting $x = 0$:

$$y(t) = 5 \cdot 10^{-5}\,\text{m} \cdot \sin(1980\,\text{s}^{-1} \cdot t) v(t) = \dot{y}(t) = 5 \cdot 10^{-5}\,\text{m} \cdot 1980\,\text{s}^{-1} \cos(1980\,\text{s}^{-1} \cdot t)$$

(e) The maximum value of the velocity is the prefactor of $v(t)$, since $|\cos_{max}| = 1$, thus:

$$|v_{max}| = 5 \cdot 10^{-5} \text{ m} \cdot 1980 \text{ s}^{-1} = 0,099\,\text{ms}^{-1}$$

Exercise 48.

(a) The amplitude of the resulting wave is:

$$A_S = 2A\cos\left(\frac{1}{2}\varphi\right)$$

For $\varphi = \pi/6$:

$$A_S = 0.04 \cdot \cos\left(\frac{\pi}{12}\right) = 3.86 \text{ cm}$$

For $\varphi = \pi/3$:

$$A_S = 0.04 \cdot \cos\left(\frac{\pi}{6}\right) = 3.46 \text{ cm}$$

(b) In order for the resulting amplitude to be equal to the original, the following condition has to be fulfilled:

$$\cos\left(\frac{1}{2}\varphi\right) = \frac{1}{2}$$

From this it follows:

$$\frac{1}{2}\varphi = \frac{\pi}{3} \qquad \text{and} \qquad \varphi = \frac{2\pi}{3} = 120°$$

Exercise 49.

In air $c = 340$ m/s:

$$\lambda = \frac{c}{f} \qquad \Rightarrow \lambda = 17 \text{ mm...21 m}$$

In He $c = 1007$ m/s:

$$\lambda = 50 \text{ mm...63 m}$$

Exercise 50.

(a) The alarm horn always has the same frequency (number of oscillations per second). In the case where the ambulance is moving towards you, you hear a higher pitched sound. Due to the fact that the wavelength gets reduced by the distance which the ambulance covers during the time of one oscillation. If the ambulance is moving away from you, you hear a lower pitched sound. The wavelength gets stretched by the same principle as described before.

(b) According to the script (page 109-9) is:

$$f_B = \frac{f}{1 - \frac{v}{c}} \qquad \Rightarrow \qquad f_B = 610 \text{ Hz}$$

given for the case that the ambulance drives towards you. For the case that the ambulance drives away from you it is [1]:

$$f_B = \frac{f}{1 + \frac{v}{c}} \qquad \Rightarrow \qquad f_B = 500.9 \text{ Hz}$$

[1]For the derivation you have to use $s = vt + v_r t$ from the script on page 109-9