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

Sheet 10 / November 7, 2017 **Solutions**

Exercise 40.

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

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

Exercise 41. 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 42.

(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:

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

Exercise 43.

(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]:

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

Additional Exercise:

(a) In general, the wave function is given by the following equation:

$$y(t, x) = y_0 \sin(\omega t - kx + \varphi_0)$$

with the initial phase shift φ_0 (angle of the phase for the position of the excitation $x = 0$ at the time $t = 0$). It applies:

$$y(0, \lambda/2) = -y_0 \text{ (wave trough)}$$

i.e.

$$y_0 \sin\left(0 - \frac{k\lambda}{2} + \varphi_0\right) = -y_0$$

$$\sin(-\pi + \varphi_0) = -1 \quad \text{with} \quad k = 2\pi/\lambda$$

$$-\pi + \varphi_0 = \frac{3\pi}{2} \qquad \varphi_0 = \frac{5\pi}{2} \equiv \frac{\pi}{2}$$

From this it follows for the wave function:

$$y(t, x) = y_0 \sin(\omega t - kx + \pi/2) = y_0 \cos(\omega t - kx)$$

(b) The velocity v is:

$$v = \lambda \cdot f = 12 \text{ m/s}$$

With the density of the robe $\rho \cdot A = 0.4$ kg/m we obtain:

$$F_0 = v^2 \cdot \rho \cdot A = 57.6 \text{ N}$$

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