

## 193. Gekoppelte physikalische Pendel

$$m = 5 \text{ kg}; \quad k = 2 \text{ N/m}; \quad a = 0.1 \text{ m}; \quad h = 0.4 \text{ m}; \quad l = 0.1 \text{ m}$$

$$\text{a) } \omega = \sqrt{\frac{mgl}{I}}$$

$$I = \frac{1}{12} m(a^2 + h^2) + ml^2 = 0.12 \text{ kg m}^2$$

$$\omega_a = \sqrt{\frac{mgl}{I}} = \underline{\underline{6.37 \text{ rad/s}}}$$

$$\text{b) } F = -m\omega^2 x; \quad \Delta x = x_1 - x_2$$

$$m\ddot{x}_1 = -m\omega_a^2 x_1 - k(x_1 - x_2)$$

$$m\ddot{x}_2 = -m\omega_a^2 x_2 - k(x_2 - x_1)$$

$$\Rightarrow m(\ddot{x}_1 - \ddot{x}_2) = -m\omega_a^2(x_1 - x_2) - 2k(x_1 - x_2) = -(m\omega_a^2 + 2k)(x_1 - x_2)$$

$$\Delta\ddot{x} = -\underbrace{\left(\omega_a^2 + \frac{2k}{m}\right)}_{= \omega_b^2} \Delta x$$

$$\omega_b = \sqrt{\omega_a^2 + \frac{2k}{m}} = \underline{\underline{6.43 \text{ rad/s}}}$$

$$\text{c) } \delta\omega = \omega_b - \omega_a$$

$$0 = \cos\left(\frac{1}{2}\delta\omega t\right)$$

$$t = \frac{2\arccos(0)}{\delta\omega} = \underline{\underline{50.29 \text{ s}}}$$

## 196. Schallgeschwindigkeit und Elastizität

$$\rho = 4500 \text{ kg/m}^3; \quad v_{\parallel} = 5050 \text{ m/s}; \quad v_{\perp} = 3100 \text{ m/s}$$

$$\text{a) } v_{\parallel} = \sqrt{\frac{E}{\rho}}; \quad v_{\perp} = \sqrt{\frac{G}{\rho}}$$

$$E = v_{\parallel}^2 \rho = \underline{1.15 * 10^{11} \text{ Pa}}$$

$$G = v_{\perp}^2 \rho = \underline{4.32 * 10^{10} \text{ Pa}}$$

$$\text{b) } \mu = \frac{E}{2G} - 1$$

$$\mu = \frac{v_{\parallel}^2}{2v_{\perp}^2} - 1 = \underline{0.33}$$

c)

$$\mu = \frac{v_{\parallel}^2}{2v_{\perp}^2} - 1 \quad \text{oder} \quad \frac{v_{\parallel}}{v_{\perp}} = \underline{\sqrt{2\mu + 2}}$$

## 199. Kompensation der Wärmeausdehnung

$$a = h = 0.1 \text{ m}; \quad \Delta T = 1 \text{ K}; \quad E = 2.1 * 10^{11} \text{ N/m}^2$$

$$\mu = 0.29; \quad \rho = 7870 \text{ kg/m}^3; \quad \alpha = 1.2 * 10^{-5} \text{ K}^{-1}$$

$$\text{a) } \frac{\Delta h}{h} = \alpha \Delta T; \quad \frac{F}{A} = E \frac{\Delta h}{h}$$

$$\frac{mg}{h^2} = E \alpha \Delta T$$

$$m = \frac{E \alpha \Delta T h^2}{g} = \underline{2568.8 \text{ kg}}$$

$$\text{b) } \Delta a_1 = \mu \Delta h; \quad \Delta a_2 = \alpha \Delta T$$

$$\Delta a_{\text{ges}} = \Delta a_1 + \Delta a_2 = \underline{1.5 * 10^{-6} \text{ m}}$$