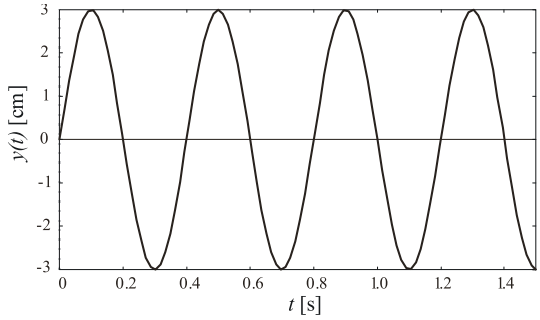
Simple Harmonic Motion

Basic Problems

1. Pick two different examples for a simple harmonic motion and choose the parameters such that their period is exactly 1.0 s.
2. A simple harmonic motion has a period of 4.5 s and an amplitude of 35 cm. Calculate its maximum speed and acceleration.
3. The amplitude of a mass oscillating on a spring is increased from 20 cm to 25 cm. How does the maximum speed change accordingly? Does the speed at 10 cm from the equilibrium position also change?
4. A mass oscillates on a spring with a period of 2.0 s. A second, identical mass is added. Calculate the new period of the pendulum.
5. The spring of a pendulum is replaced by another spring, increasing the period by 10 %. Calculate the percentage change in the spring's elastic constant.
6. A simple harmonic motion is characterised by the formal equation $r\, a_y(t) + s\, y(t) = 0$. Find a formal expression for the period.
7. An LC oscillator with capacitance 47 nF has a frequency of 3.7 kHz. Calculate the inductance of the circuit. The inductance is increased by a factor of 4.5 by introducing an iron core into the coil. How does this affect the oscillation frequency?
8. The wheels of a car with mass 1.9 t are suspended by springs with (total) elastic constant 135 kN/m. When the car drives over a speed bump, The springs are compressed by 11.5 cm. Calculate the initial total energy and the maximum vertical speed of the resulting oscillation.
9. At 30 cm displacement the kinetic energy of a mass in simple harmonic motion is half of its potential energy. Calculate the oscillation's amplitude.
10. A capacitor with capacitance 150 nF is charged on 5.5 V and then connected to a coil with inductance 6.8 mH. Calculate the current flowing when the voltage across the capacitor has dropped to 2.5 V in two different ways.

Additional Problems

11. A mass of 550 g is attached to a spring with spring constant 8.2 N/m. The mass is displaced by 20 cm from its equilibrium position and let go at $t = 0$. Draw graphs for the displacement, velocity and acceleration vs. time.
12. The figure below displays the oscillation of a mass on a spring (displacement vs. time). The pendulum mass is 470 g. Determine the oscillation's period, angular frequency, frequency, amplitude and total energy. Calculate the elastic constant of the spring.



13. A test tube is immersed in a liquid to a height h_0. After a slight push it starts oscillating around its equilibrium position.
    a) Show that the motion of the test tube is a simple harmonic motion. Derive a formal expression for the oscillation period.
    b) Calculate the period for a test tube with diameter 2.5 cm and mass 65 g in water.

Solutions: 2. 0.49 m/s, 0.68 m/s²; 3. +25 %, yes; 4. 2.8 s; 5. − 17 %; 6. $2\,\pi\,(r/s)^{½}$; 7. 39 mH, − 53 %; 8. 890 J, 0.97 m/s, 8.2 m/s²; 9. 37 cm; 10. 23 mA; 11. $T = 1.6$ s; 12. 0.4 s, 15.7 rad/s, 2.5 Hz, 3 cm, 52 mJ, 120 N/m; 13. $2\,\pi\,(m/\rho\, A\, g)^{½}$, 0.73 s