

WAVE MECHANICS, FYSA13

Tuesday, August 25, 2020

Allowed material: The enclosed formulas and a calculator.

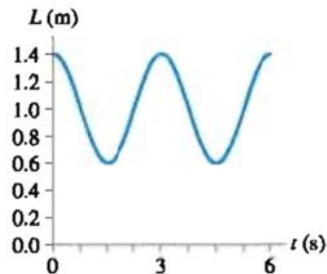
Total number of points: 20. Points required to pass: 10

The following values can be used in the problems below:

The speed of sound in air is 343 m/s and the density of air is 1.20 kg/m^3 . The speed of sound in water is 1484 m/s and the density of water is 997 kg/m^3 . The speed of light is $3.00 \times 10^8 \text{ m/s}$. The gravitational acceleration is 9.82 m/s^2 and $1 \text{ m/s} = 3.6 \text{ km/h}$.

V1

Astronauts in space cannot weigh themselves by standing on a bathroom scale. Instead, they determine their mass by oscillating on a large spring. Suppose an astronaut attaches one end of a large spring to her belt and the other end to a hook on the wall of the space capsule. A fellow astronaut then pulls her away from the wall and releases her. The spring's length as a function of time is shown in the figure below.



- What is her mass if the spring constant is 240 N/m ? (2 p)
- What is her speed when the spring's length is 1.2 m ? (2 p)

V2

Biologists think that some spiders “tune” strands of their web to give enhanced response at frequencies corresponding to those at which desirable prey might struggle. Orb spider web silk has a typical diameter of $20 \mu\text{m}$, and spider silk has a density of 1300 kg/m^3 . To have a fundamental frequency at 100 Hz , to what tension must a spider adjust a 12-cm -long strand of silk? (4 p)

V3

On famous Bondi Beach in Sydney, Australia they have a siren warning swimmers about sharks. The siren produces a sinusoidal wave with a frequency of 4000 Hz and it is designed so that it can be heard at the end of the beach which is 450 meters away from the siren with an intensity level of 65 dB .

- Calculate the intensity level at a distance of 3 m away from the siren. You can assume that the siren sends out soundwaves uniformly in all directions.
- What is the wave function that describes the sound from the siren at the end of the beach (assume that the phase angle is zero)?
- What is the maximum velocity of the air molecules caused by the sound wave at the end of the beach?

V4

A Michelson interferometer is used to determine the wavelength of light from a Krypton laser.

- a) Draw a sketch of a Michelson interferometer that sends laser light to a screen and briefly explain how the interferometer works and the parts it consists of. (2 p)
- b) In a measurement, interference rings from the laser on a screen are studied. By turning a micrometer screw so that a part of the device moves $9.7 \mu\text{m}$, one get 30 interference rings to pass past the same point on the screen. What is the wavelength of the laser light? (2 p)

V5

Light from a HeNe laser with a wavelength of 632.8 nm is sent on to a broad slit such that a diffraction pattern is formed on a screen 4.00 meters away from the slit.

- a) How wide is the slit if the center of the first dark band is 15.0 mm from the center of the bright central line. (2 p)
- b) What is the difference in phase angles of light rays coming from the top and the bottom of the slit at a point 10.0 mm from the middle of the bright central line ? (2 p)
- c) If the light intensity is 1.83 mW/mm^2 in this point, what is the maximum light intensity in the diffraction spectrum on the screen ? (2 p)