WAVE MECHANICS, FYSA13

Friday, June 5, 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 3.00x10^8 m/s. The gravitational acceleration is 9.82 m/s^2 and 1 m/s = 3.6 km/h.

V1
A 4.00 kg block hangs from a spring, extending it 16.0 cm from its unstretched position.

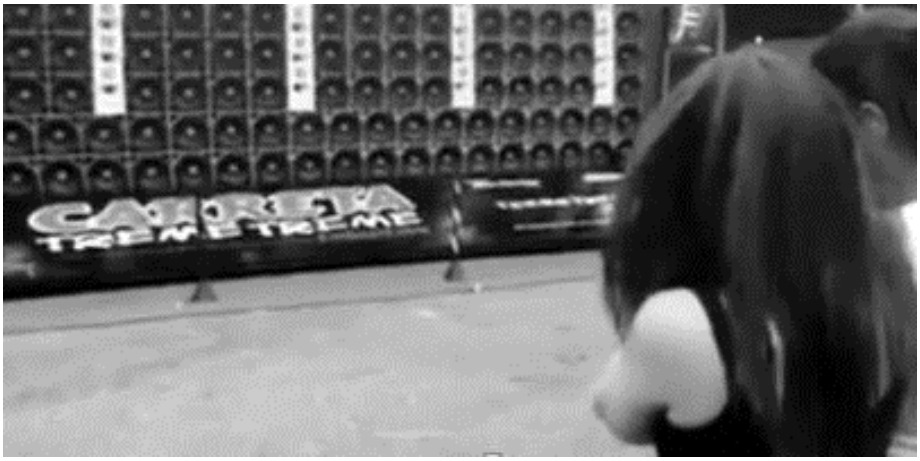
a) What is the spring constant? (2p)
b) The block is removed, and a 0.500 kg body is hung from the same spring. If the spring is then stretched and released, what is its period of oscillation? (2p)

V2
A string that is stretched between fixed supports separated by 75.0 cm has resonant frequencies (normal modes) of 420 and 315 Hz, with no intermediate resonant frequencies.

a) What is the lowest resonant frequency? (2p)
b) What will be the lowest resonant frequency if we double the tension in the string without changing anything else? (2p)

V3
Vincent has found a youtube video with the Brazilian loudspeaker truck Carreta Treme Treme in which a girl's hair is moved by the soundwaves (see photo below). To see if this can be true he makes a simple back-of-the-envelope calculation under the assumption of a sinusoidal sound wave with frequency 30 Hz and intensity level 130 dB.

a) What will then be the displacement amplitude? (2 p)
b) What will be the maximum pressure variations that the sound wave produces? (2 p)



V4

Light from a HeNe laser with a wavelength of 632.8 nm is sent to two narrow slits so that an interference pattern is formed on a screen located 3.00 meters from the slit. The maximum light intensity on the screen is 2.00 mW/mm^2. The angles to the bright bands in the interference pattern on the screen are so small that one can make the approximation $\sin(\theta) = \tan(\theta) = \theta$ where θ is the angle between the normal to the plane of the slits and a line from the slits to a point on the screen.

a) What is the distance between the slits if the angle to the middle of the first dark band on the screen is 0.2 degrees? (2 p)

b) What is the smallest angle θ for which one will have an intensity of 0.70 mW/mm^2 (2 p)

V5

A low-pressure sodium lamp produces a light spectrum from the two sodium emission lines with 589.00 and 589.56 nanometres wavelength. It is studied with a 10 mm wide grating in a spectrometer like the one in the figure below.

a) If the second-order diffraction line is found at $\theta = 64.56$ degrees for the 589.00 nm light, at what angle should one find the light from second-order diffraction of light with 589.56 nm wavelength ? (2 p)

b) What chromatic resolving power is needed to see both emission lines at second order? What chromatic resolving power do we expect the grating to provide? (2 p)