WAVES, FYSA13

Friday, June 4, 2021

Allowed material: The formula sheets from the exam webpage (printed!) 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 wave on a string is described by

$$y(x,t) = 15.0\sin(\pi x/8\ - 4\pi t)$$

where *x* and *y* are in centimeters and *t* is in seconds.

a) What is the transverse speed for a point on the string at $x = 6.00$ cm when $t = 0.250$ s? (1 p)
b) What is the maximum transverse speed of any point on the string? (1 p)
c) What is the magnitude of the transverse acceleration for a point on the string at $x = 6.00$ cm when $t = 0.250$ s? (1 p)
d) What is the magnitude of the maximum transverse acceleration for any point on the string? (1 p)

V2

A solid ball of aluminium (density 2600 kg/m^3) is suspended from a light spring and oscillates with a frequency f_1. Another solid ball, with the same radius r_1, oscillates on the same spring with a frequency $f_2 = 0.55\ f_1$.

a) Calculate the density of the material of the second ball. (2 p)
b) Assume that the spring constant of your spring is 100 N/m and that you have a series of solid balls of different densities, but all of the same radius, that you can suspend from the spring. Sketch the frequency *f* as a function of the density ρ (of the ball material) for a constant value of 1.2 cm of the radius of the ball. (2 p)

V3

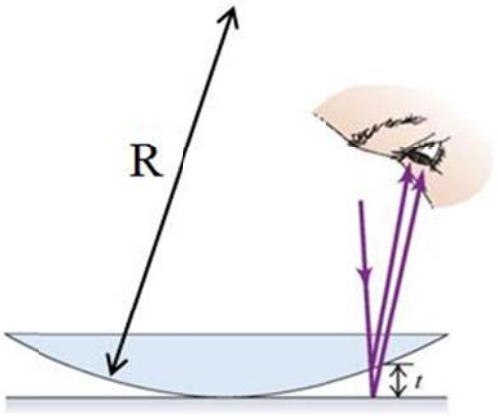
The group "The Offspring" plays the song “Let the bad times roll” in Folketspark in Malmö where the air temperature is 15 degrees Celsius and the air density is 1.225 kg/m^3. One week later they play the same song in Bologna where it is 35 degrees Celsius and the density is 1.146 kg/m^3. The air pressure is the same during the two gigs, which means that the bulk module for the air is also the same.

a) How many percent different will the sound intensity be in Bologna compared to Malmö for a wave with the same frequency and displacement amplitude? (2 p)
b) What will be the difference in decibels between a soundwave in Malmö and Bologna if the two soundwaves have the same frequency and displacement amplitude ? (2 p)

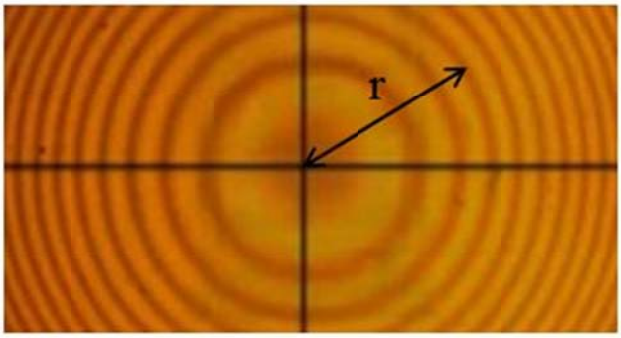
V4

With the help of a microscope one can study Newton's rings produced in a plano convex lens as shown in the figure below. The lens has a radius of curvature which is R = 80.0 cm and an index of refraction that is n = 1.50. The lens is placed on a glass plate with index of refraction n = 1.57.

a) What is the distance t between the lens and the glassplate at the fifth ring if a Sodium lamp with wavelength 589 nm is used? (1 p)
b) When using a mercury lamp, the radius of the third dark ring is measured to be r = 1.14 mm. What is the wavelength of the light from the mercury lamp? (2 p)



Side view



Top view

V5

Light from a HeNe laser with a wavelength of 632.8 nm is sent to a set-up with several slits which are separated by 0.800 mm and which each have a width of 0.200 mm. The figure below shows the calculated intensity distribution of the diffraction spectrum on a screen 245 cm away from the slits and the envelope distribution. The maximum intensity in the spectrum is 2.00 mW/mm^2.

a) What is the number of slits (motivate the answer)? (1 p)
b) There will be a broad dark band where the envelope has a minimum as indicated by the arrow. What is the angle to the screen at this point? (2 p)
c) What is the intensity at the peak in the diffraction spectrum that is indicated by an arrow? (2 p)