Practice Exam 5 for Physics 205/210

Useful Data

gravitational constant	$G = 6.67 \times 10^{-11}$ N·m^2/kg^2
Coulomb constant	$k = 8.99 \times 10^9$ J·m/C^2 or N·m^2/C^2
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ J/K
quantum of charge	$e = 1.60 \times 10^{-19}$ C
speed of light	$c = 3.00 \times 10^8$ m/s
Planck's constant	$h = 6.63 \times 10^{-34}$ J·s
absolute zero	$-273.15\,^\circ$C
speed of sound in air	340 m/s
mass of electron	9.11×10^{-31} kg

1 A certain radio station operates at 95.1 MHz. Find the period, velocity, and wavelength of the radio waves.

2 A mechanical oscillator is redesigned so that its mass is greater by 17.3%, without changing its Q. Find the effect that this has on the width of the resonance.

3 A wave with amplitude I encounters the boundary between two media. Exactly half of its energy is reflected and half transmitted. Find as much information as possible about the amplitude R of the reflected wave. Why is it not true that the amplitude T of the transmitted wave is the same as R? (You do not need to calculate T.)

4 An organ pipe with a length of 0.85 m produces a frequency of 300 Hz under conditions of standard temperature, etc. Determine the standing-wave pattern and sketch it as a graph. Determine whether the pipe acts like a symmetric air column (open-open or closed-closed) or an asymmetric one (open-closed).

Answer to problem 1
The velocity is the speed of light, $v = 3.0 \times 10^8$ m/s (given in the data table at the top of the exam — don't memorize numbers like this). The period is $T = 1/f = 1.05 \times 10^{-8}$ s. The wavelength is $\lambda = v/f = 3.15$ m.

Answer to problem 2
We have $\omega = \sqrt{k/m}$, so the frequency of the resonance is proportional to $m^{-1/2}$. The width of the resonance is proportional to the frequency, for a fixed Q, so the width is also proportional to $m^{-1/2}$. Raising m by a factor of 1.173 causes the width to change by a factor of $1.173^{-1/2} = 0.923$, a decrease of 7.7%.

Answer to problem 3
The energy of a wave is proportional to the square of its amplitude, and the constant of proportionality depends on the medium. The reflected and incident waves are in the same medium, so $E_R/E_I = (R/I)^2$, and we find that $R = \pm I/\sqrt{2}$. The given information does not determine the sign. Since the incident and transmitted waves are in different media, it is not true that $E_T/E_I = (T/I)^2$.

Answer to problem 4
The speed of sound, 340 m/s, is given in the table of data at the top of the exam. (Don't memorize numbers such as this one.) The wavelength of the sound wave is therefore $\lambda = v/f = 1.13$ m. If the length of the pipe is L, we have $L/\lambda = 0.75$, i.e., 3/4 of a wavelength fits in the pipe. Since this isn't a whole number of half-wavelengths, the wave pattern has a node at one end and an antinode at the other, and the pipe is behaving as an asymmetric air column. If we start tracing out a sine wave with our pen, and stop after having completed 3/4 of a wavelength, the wave pattern looks like this:  .