Psychoacoustics

Pantelis N. Vassilakis Ph.D.

Module 2 Homework (Acoustics)

Student Name: _____

1) (*2pts*) **Write the mathematical expression for a simple harmonic motion (*i.e.* displacement *y* as a function of time *t*) with frequency *f*, amplitude *A*, and initial phase φ**

2) (*5pts*) **Write the values for *T(sec/cycle)*, *f(Hz)*, *A*, and φ *(degrees)* for the signal in the figure, below, including units where needed, and use 3 of these 4 values to write the sinusoidal equation of displacement *y(t)* for this signal (*i.e.* as in the previous question but with actual values inserted)**

T =

f =

A =

φ =

y(t) =
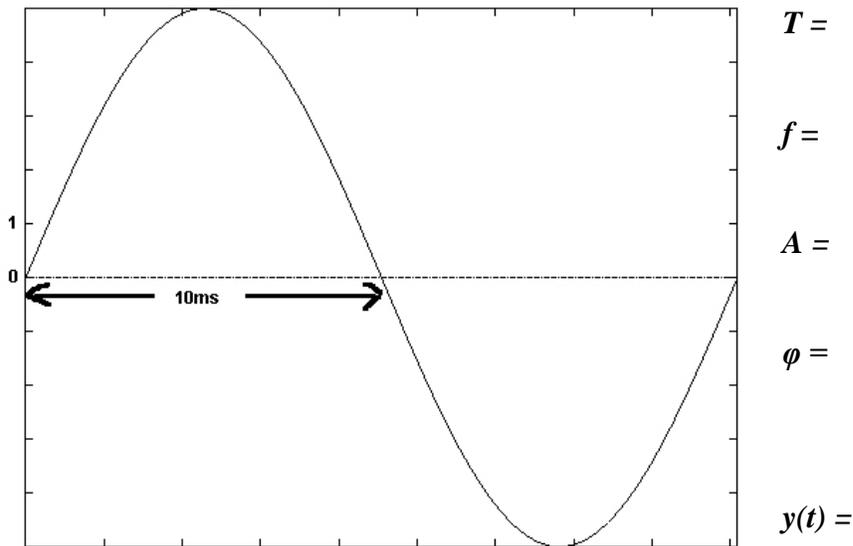
3) (*6pts*) **What are the two main reasons for using log rather than linear math to describe sound intensity?**

a)

b)

4) (*8pts*) **Complete the following equations** *(show your work)***:**

a) 50dB SIL = _____ W/m^2

b) 10^{-3} W/m^2 = _____ dB SIL

c) 50dB SIL + 50dB SIL = _____ dB SIL

d) 10 * 50dB SIL= _____ dB SIL

5) (*6pts*) **Fill-in the blanks**

a) (*1pt*) Doubling the intensity of a sound results in a SIL increase by _____ dB

b) (*1pt*) Doubling the pressure of a sound results in a SPL increase by _____ dB

c) (*1pt*) Regarding a vibration's amplitude A and frequency f, intensity is proportional to _____ and _____ respectively

d) (*2pts*) The strongest intensity that can be safely heard (*i.e.* threshold of pain) is _____ W/m^2 (I) or _____ dB (SIL), or _____ Pa (Pressure)

e) (*1pt*) For sinusoidal signals, P_{rms} = _____ * P_{Peak}

6) (*6pts*) **Assuming c = 345m/sec at 20^0 Celsius, what is the wavelength λ (including units) of a sinusoidal wave with f = 50Hz at** *(show your work)***:**

   a) 20^0 Celsius?

   b) 25^0 Celsius?

7) (*4pts*) **How much delay will have to be applied to speakers placed at the far end of a 90m-long auditorium for the sound from the speakers to be in synch with the sound arriving directly from the stage** (*assume c = 360m/sec – show your work*)?

8) (*12pts*) **Fill-in the blanks**

   a) (*1pt*) In transverse waves, energy moves _____ to the direction of the vibration of the medium's particles while, in longitudinal waves, energy moves _____ to the direction of the vibration of the medium's particles.

   b) (*2pts*) Standing waves arise in a medium when vibrational energy is _____ _____ rather than moving through them. The creation of standing waves is the result of

   _____

   c) (*2pts*) According to the Inverse Square Law, if the intensity level of a sound wave 1m from the source is 50dB, it will drop to _____ dB, 10m away from the source *(show you work).*

d) (*3pts*) Fourier analysis is the process of analyzing a complex signal into its

_____ _____. Periodic signals are also called

_____ and give rise to a quite definite _____ sensation. In such

signals, all _____ have frequencies that are _____

_____ of the frequency of the lowest _____, which is also

called _____. A graph that displays the frequency and amplitude

values of all _____ _____ in a complex

signal is called _____.

e) (*2pts*) Assuming the amplitude of the 1st component of a complex signal is 1,

the amplitude of the 4th component will be _____ for an ideal sawtooth signal and

_____ for an ideal square signal, while

the amplitude of the 3rd component will be _____ for an ideal triangle signal and

_____ for an ideal square signal.

f) (*2pts*) Resonance occurs when a system is driven at a _____ equal to its

_____, resulting in a [*choose between* maximum *and* minimum]

_____ amount of energy transfer.

9) (*6pts*) The violation of two assumptions in the standard application of Fourier analysis has one main undesirable side-effect. List the two assumptions and the one side-effect.

Assumption 1:

Assumption 2:

Undesirable side-effect:

10) (*4pts*) **What is the total noise sound intensity level (in dB) of a 1000Hz-wide band of noise with noise spectrum level of 40dB?** *(show your work)*

11) (*4pts*) **Modulating the amplitude of a sine ($f = 300$Hz and $A = 1$) with $f_{mod} = 10$Hz and *modulation depth* (modulation index) = 50% will introduce two sidebands with**

$f_1 = $ _____   - $A_1 = $ _____

and

$f_2 = $ _____   - $A_2 = $ _____

12) (*6pts*) **The natural frequency of a Helmholtz resonator is 200Hz. What will this frequency be if the resonator's neck becomes 4 times longer?** *(show your work)*

13) (*10pts*) **Fill-in the blanks**

a) (*1pt*) The angle of reflection is _____ the angle of incidence.

b) (*1pt*) When a sound wave crosses two media, the larger the _____ _____ between the two media the larger the proportion of reflected versus transmitted sound energy.

c) (*1pt*) Reverberation time is defined as the time it takes for a sound to lose _____dB of its original level.

d) (*2pts*) The ability of sound waves to bend around obstacles & through openings whose smallest dimension is _____ than the waves' wavelength is called

_____.

e) (*1pt*) A moving sound source will create a shock wave if _____.

f) (*1pt*) Bernoulli's principle of linear superposition states that the total displacement of two or more superimposed vibrations is equal to _____

_____.

g) (*3pts*) Adding two sine signals with slightly different frequencies f_1 & f_2 results in a complex signal whose amplitude fluctuates between a max and a min value because

_____

_____

_____

14) (*6pts*) **I) In *Figure 1*, below, will listener *A* be more likely to hear the bass guitar or the flute sound coming from the stage, *S*, and why?**
II) In *Figure 2*, below (point-source S positioned at the middle opening), which listener (A or B) is more likely to hear the bass guitar louder and why?
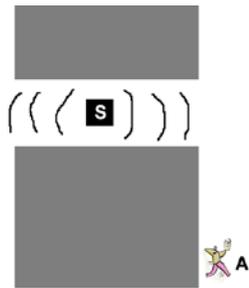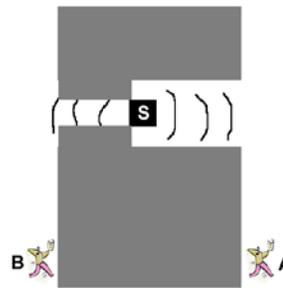
Figure 1   *Figure 2*

I):

II):

15) (*3pts*) **Match the mathematical expressions to the figures, below, by writing A, B, or C, next to each expression (v_1 = sound speed in Medium 1; v_2 sound speed in Medium 2).**

$v_2 = v_1$ _____ $v_2 > v_1$ _____ $v_2 < v_1$ _____

| A | B | C |
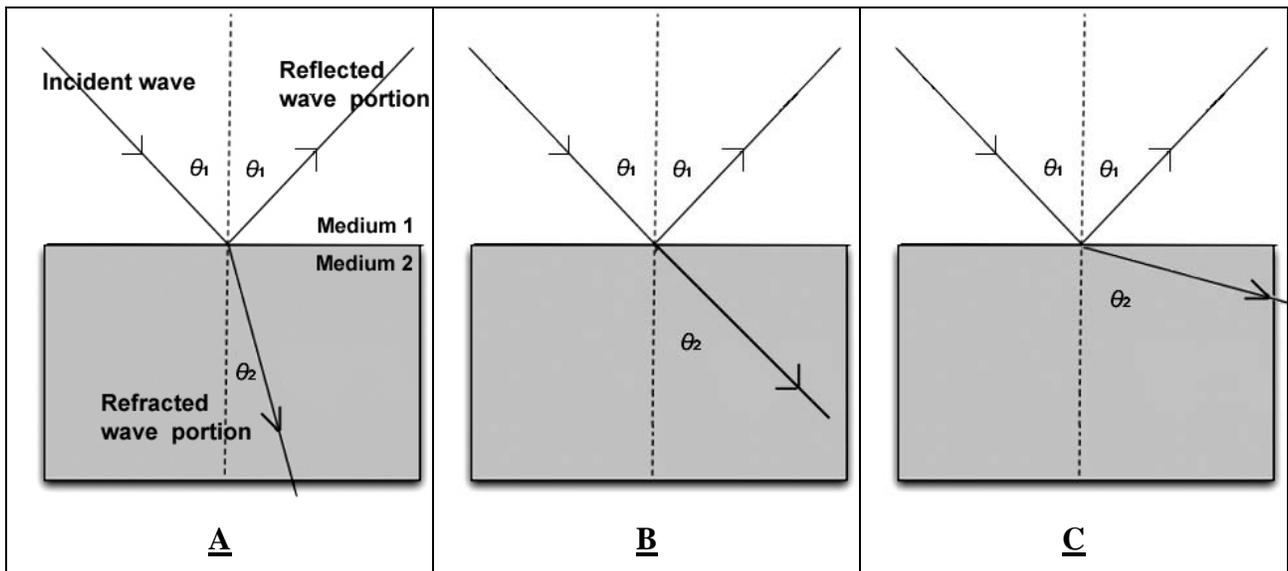
16) (*12pts*) **Fill-in the blanks**

I) (*4pts*) Musical instruments can be seen as systems that involve three physical components:

a) _____ b) _____ and c) _____.

A force exciting (a) will affect the resulting signal's spectrum as follows: forces applied close

to structures supporting (a) will give spectra richer in _____ frequencies and

forces applied during a long contact with (a) will be give spectra richer in

_____ frequencies.

The function of (b) is to produce the desirable amount of _____ matching between (a) and (c), allowing for the proper balance between _____ and _____ energy.

The shape and materials of (c) should be such as to amplify a range of _____ that matches, as much as possible, the playing range of the instrument.

II) (*1pt*) Similar to the long-time average spectrum of noise, the spectrum of an impulse signal has [number] _____ components with, in general [chose between *equal & unequal*] _____ amplitudes.

III) (*2pts*) The cutoff frequencies of a band-pass filter are defined in terms of a) _____dB bandwidth, b) _____dB bandwidth, or c) ERB (spell this out)_____

_____

The Q of a band-pass filter is defined as _____

_____.

IV) (*3pts*) A system is nonlinear if its output is _____ of the input. In terms of sound signals, nonlinear systems output spectral components not present in the input signal, which are called _____products. The two most common types of such nonlinearity are _____ _____ and _____

 _____.

V) (*2pts*) The Nyquist-Shannon sampling theorem states that a signal must be sampled at a rate (samples/sec) equal to _____ the largest frequency to be sampled. The bit depth (bits/sample) determines the _____

_____ that can be digitally represented.

16bit sampling can represent a _____ _____ of _____ dB.