PHYS 536 final exam

All work on this exam must be your own. Open books and notes.
There are 10 questions, multiple choice.
Using any text editor (Word, TextEdit, Notepad, etc), type in the letter of the best answer for each question in the answer sheet provided as the last page.
Choose only one answer for each question.

1. Standing waves are produced in 10m long stretched string. If the string vibrates in 5 segments and wave velocity is 20m/s, its frequency is

   a) 2Hz
   b) 4Hz
   c) 5Hz
   d) 10Hz

Answer: c
$5\times \lambda/2=10 \rightarrow \lambda=4$m
v=20m/s
$f=v/\lambda=20/4=5$Hz.

2. The frequency of a tuning fork is 256. It will NOT resonate with a fork of frequency

   a) 256
   b) 512
   c) 738
   d) 768

Answer: c
Tuning fork of f = 256Hz will resonate with forks of integer-multiples of f such as 256, 768, 1024 etc. It will not resonate with a fork of frequency 738Hz, which is not an integral multiple of 256Hz.

3. An organ pipe closed at one end has a fundamental frequency of 1500Hz. The maximum number of *overtones* (number of harmonics above the fundamental) generated by this pipe, which a normal person can hear is

   a) 12
   b) 9
   c) 6
   d) 4

Answer: c
Normal human can hear frequencies up to 20000Hz.
For a closed-open organ pipe, $f_n=n\, f_1$ where n must be *odd* integer
($f_1 = c/\lambda_1$; for closed-open pipe, $\lambda_1 = 4L$, $f_1 = c/4L$ – but not needed here)
Must have $20000 \text{ Hz} \geq n\times 1500 \text{ Hz} \rightarrow n \leq 13.3$
So $n_{max} = 13$; allowed harmonics are: 1, 3, 5, 7, 9, 11, 13 → N=7 audible *harmonics*
2nd harmonic = 1st overtone (see Kinsler p.46) so max number of *overtones*= 7-1 =6.

4. A closed organ pipe and an open pipe of the same length produce four beats per second, when sounded together. If the length of the closed pipe is increased, then the number of beats will

a) Increase
b) Decrease
c) Remain the same
d) First decrease, then remain the same

Answer: a

Beat frequency = $f_{open} - f_{closed} = f/(2L_{open}) - f/(4L_{closed})$

If the length of the closed pipe is increased, f_{closed} will decrease, so the beat frequency will increase.

5. When the amplitude of a sound pressure wave is doubled, the sound pressure level (in decibels)

a) is doubled.
b) is halved.
c) decreases by 2 dB.
d) increases by 6 dB.

Answer: d

$SPL=20\log10(p/p_0) \rightarrow 20\log10(2)=6dB$

(or: $SPL = 10\log10(I/I_0)$, where $I \sim p^2$, so $10\log10(4)= 6dB$)

6. The trigonometric Fourier series of an even function of time does not have the

a) dc term
b) cosine terms
c) sine terms
d) odd harmonic terms

Answer: c

if f(t)=f(-t) —> even function, only cos(nt) terms appear, including n=0 (constant term). In the general case, there is no odd or even n limitation.

7. Within reasonable limits, which of the following should NOT affect the fundamental frequency of vibration of a string?

a) changing the amplitude of vibration.
b) changing the tension of the string.
c) changing the length of the string.
d) changing the linear density (mass per meter) of the string.

Answer: a

For a string, f_0 = sqrt(tension/density)/(2 x length), so only amplitude is not relevant

8. Two pure tones cause resonance in different positions along the basilar membrane in the cochlea.
These tones have different

a) amplitude.
b) frequency.
c) timbre.
d) reverberation

Answer: b
Different frequencies stimulate different regions of the cochlea; position of resonance along the basilar membrane is they key factor in pitch (frequency) perception.

9. What is the sound pressure level (SPL) of a sound having a RMS pressure of 200 N/m^2 ?

a) 150 dB
b) 140 dB
c) 170 dB
d) 160 dB

Answer: b
SPL = 20 log10 (p/po) dB, with p0=20 microPa →20 log10(2e+2/2e-5)=20 x 7

10. What is the resonant frequency of a Helmholtz resonator whose volume is 2.5 cubic m with neck radius of 0.08 m and effective neck length of 0.135 m ? (use c=331 m/s)

a) 13 Hz
b) 11 Hz
c) 15 Hz
d) 14 Hz

Answer: a
For a Helmholtz resonator, f_0= (c/2π) sqrt[A/VL], where A,L=neck area and length, V=volume