

Midterm Exam – FS20 McCaskey TAKE-HOME PORTION

Instructions

For numerical problems, **show your work** and express your answer in the proper **units** or you **will** lose credit. If you want to use notes, I won't stop you, but please **work by yourself**.

$$T = \frac{1}{f} \quad T = 2\pi\sqrt{\frac{m}{k}} \quad T = 2\pi\sqrt{\frac{l}{g}} \quad PE = mgh \quad KE = \frac{1}{2}mv^2$$

$$v = f\lambda \quad v = 331 + 0.6T(^{\circ}C) \quad F = \frac{9}{5}C + 32 \quad C = \frac{5}{9}(F - 32) \quad v = \sqrt{\frac{F_T}{\mu}}$$

$$speed = \frac{distance}{time} \quad \lambda = 2(NN) = 4(NA) \quad f_{beat} = |f_1 - f_2| \quad f_0 = f_s\left(\frac{v \pm v_o}{v \pm v_s}\right)$$

$$g = 9.8 \text{ m/s}^2 \quad a^2 + b^2 = c^2 \quad f = f_0 \times 2^{n/12} \quad |d_1 - d_2| = n\lambda \text{ (const. int.)}$$

For the mathematical wave form $y = A \sin(kx - \omega t)$, $k = \frac{2\pi}{\lambda}$, $\omega = 2\pi f = \frac{2\pi}{T}$, $v = \omega/k$

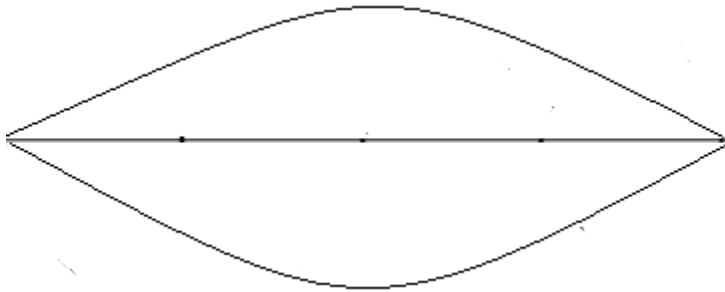
Parts 1 and 2 are multiple choice and short answer – do these on Canvas.

It probably doesn't matter which order you do the sections in. If any of you has trouble accessing the Canvas part, email me and let me. It's called "Midterm exam online portion."

Part 3: Numerical problems (SHOW YOUR WORK and submit online!)

16. A pendulum vibrates back and forth and takes 18 seconds to complete 12 cycles. If the angle of oscillation is small, say, 5° either way, find (a) the period and (b) the frequency of the oscillations. (c) If we change the angle to 10° , that's still a pretty small angle and our formula says the period should be the same because amplitude isn't involved. How is it possible for this pendulum to swing through twice the distance in the same amount of time? (6 pts. total)

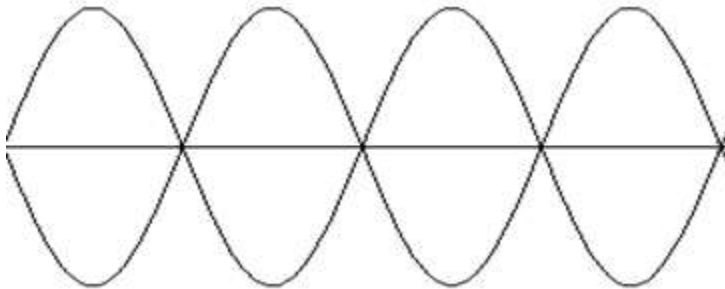
17. A string has density $\mu = 0.00057 \text{ kg/m}$. It is vibrating in the fundamental mode and is tightened with a tension force of 103 N. A picture of this vibration is below.



(a) What is the speed of the waves that produce this standing wave pattern? (2 pts.)

(b) If this string vibrates at 329 Hz, what is the length of the string? (4 pts.)

(c) A cool guitar trick is to play the fourth harmonic by creating a node on the string, making it vibrate like this (I've chosen the numbers above to be like a high E string):



Think about the **wavelength**, **wave speed**, and **frequency** of this harmonic. Which of these are **different** from the picture in part (a) if the string isn't tightened differently? (3 pts.)

17 (d) You probably made a pattern that looks like this in lab. In it, the antinodes are several centimeters tall even though the vibrating machine only moves up and down a few millimeters. How is this possible? (2)

18. The decay half-time of a mass/spring system in damped harmonic motion is 20 seconds. At $t = 0$ seconds, we start the oscillation. Find the amplitude at the following times: (4)

Time	0 s	20 s	40 s	60 s	2 minutes
Amplitude (cm)			2		

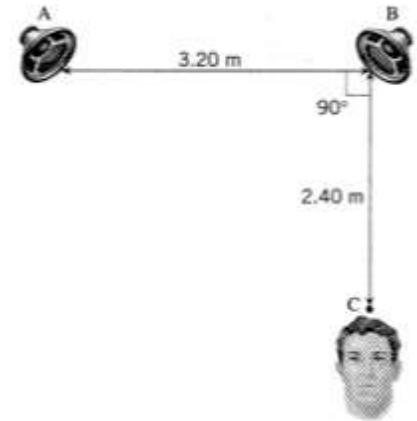
19. (8 pts.) An ambulance siren makes a 300 Hz sound when the vehicle is not moving.

(a) If the ambulance moves in a certain way (assume you are not moving), you will hear a tone a semitone (one half-step) lower. What frequency is that in Hz (using 12-TET)? (2)

(b) Is the ambulance approaching you or moving away from you? How do you know? (2)

(c) Find how fast the ambulance would have to be moving to create that lower siren note. You should be able to do this with algebra – and you can assume the speed of sound in air is 337 m/s for this problem. (4)

20. The figure at right shows two loudspeakers playing in phase. A and B are separated by a distance of 3.2 m, and a listener is stationed at point C, 2.4 m in front of speaker B. Both speakers are being tested by playing identical 107 Hz tones, and the speed of sound in air is 343 m/s.



(a) What's the wavelength of the tones? (2 pts.)

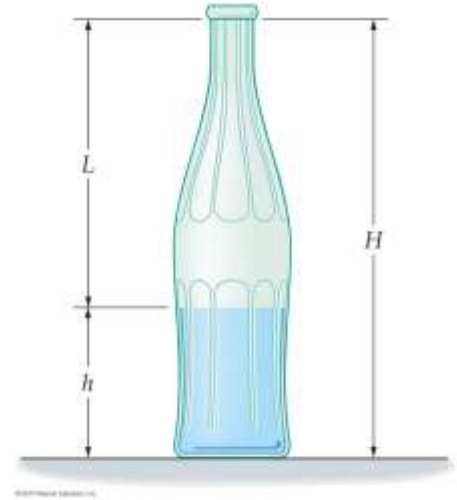
(b) How many wavelengths of this sound separates the listener from **each** speaker? (3 pts.)

(c) Will the listener hear a sound louder than a single speaker, basically no sound, or something else? Explain how you know using ideas of wave interference. (4 pts.)

(d) Is every person and thing in this problem practicing correct social distancing? (1 pt.)

21. What we've seen with the resonance tube in lab applies to making music with glass bottles (partly filled with liquid). Suppose we want this bottle to play a fundamental frequency of 392 Hz when we blow across the top. Assume the temperature is 20°C. (3 for a, 4 for the others)

(a) What wavelength will the sound have at this frequency and air temperature?



(b) If the bottle is $H = 24$ cm tall, what's the height of water h needed to produce 440 Hz? Don't worry about the curvature of the sides. Sketching a standing wave that fits in the bottle helps.

(c) If you use the same bottle and water level, in theory you can get higher harmonics. What is the frequency of the next higher harmonic possible?

(d) What would the 392 Hz fundamental frequency become if, given the same amount of liquid inside, we took the bottle outside where the air temperature is 5°C?

22. A 2.0 kg missile is launched upward from the ground at a velocity of 4 m/s. Ignore air resistance. (2 pts. each part, 8 total)

(a) How much kinetic energy does the missile have at ground level?

(b) The missile will have the same amount of potential energy at the top of its path. How high above ground will it be at that point?

(c) How many times more KE (compared to part a) will it start with if it's launched at 8 m/s?

(d) Will the rocket make it twice as high as part (b), or some other distance?

23. (3 pts) If wave A is written in the form $y = 3 \sin(\pi x - 2\pi t)$ and wave B is written in the form $y = 2 \sin(x - 2t)$ (with all numbers expressed in standard SI units), which **if either** has (a) the higher amplitude? (b) the higher frequency? (c) the higher wave speed? Briefly explain.

Bonus question on next page

Bonus question (up to 5 pts.): If you graph your pendulum lab data by putting period squared (in square seconds) on the y-axis and string length (in m) on the x-axis, and the value of g you get is correct (9.8 m/s^2), what was the slope of your trendline? Please include units!

END OF EXAM. Good luck! Please submit your work on these problems electronically and stay tuned to Canvas for scores and updates.