4. The end of one of the prongs of a tuning fork that executes simple harmonic motion of frequency 1000Hz has an amplitude of 0.40mm. The speed of the end of the prong when the end has a displacement of 0.20mm is

a. ± 2.5 m/s
b. ± 2.2 m/s
c. 2.2 m/s
d. 2.5 m/s
e. None of the above, my answer is ____________

5. A particle has a displacement $x = 0.5\cos\left(3t + \frac{\pi}{4}\right)$, where x is in meters and t is in seconds. At what time does the maximum velocity occur for the second time?

a. 1.31 s
b. 2.09 s
c. 2.37 s
d. 3.40 s
e. None of above, my answer is ____________

6. A commuter train passes a passenger platform at a constant speed of 0.040 km/s. The train horn is sounded at its characteristic frequency of 320 Hz. The change in frequency detected by a person on the platform as the train passes is

a. 902.28 Hz
b. 1.102 Hz
c. 902.28 cycles/s
d. 320.04 Hz
e. None of the above, my answer is ____________

7. A search ship equipped with Sonar technology detects a sunken submarine 12 seconds after the first signal was emitted from the sonar exactly when the ship was above the submarine. Considering that speed of sound in seawater is 1522 m/s, the depth at which the submarine has sunken is

a. 18264 m
b. 9132 m
c. 17 km
d. 10 km
e. None of the above, my answer is ____________

8. A source emits 10^{-4} W/m² of sound isotropically. A small microphone located at 100 m from the source intercepts the sound in an area of 0.500 cm². The power of sound at the microphone's location is:

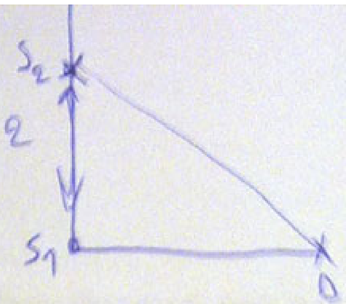
- **a.** 5 nW
- **b.** 13 kW
- **c.** 12.57 W
- **d.** 5 W
- **e.** None of the above, my answer is ________

9. In certain ranges of piano keyboard, more than one string is tuned to the same note to provide extra loudness. For instance, the note at 110 Hz has two strings (with the same mass per unit length μ) that vibrate at this frequency. If one string slips from its normal tension of 600 N to 540 N and if λ is the same on both strings, the beat frequency heard when the hammer strikes the two strings simultaneously is:

- **a.** 8 beats/s
- **b.** 8 cycles/s
- **c.** 104.36 Hz
- **d.** 5.64 Hz
- **e.** None of the above, my answer is ____________

10. A jet plane passes over you at a height of 5000 m and a speed of Mach 1.5. After the jet passes directly overhead, the time taken by the shock wave to reach you is (use 331 m/s for the speed of sound):

- **a.** 16 s
- **b.** 16.78 s
- **c.** 22.58 s
- **d.** 15.05 s
- **e.** None of the above, my answer is ____________



PART II

Problem 1

Two loudspeakers S1 and S2 are located 2.00 m apart on the vertical y axis. It is important to mention that S1 is at the origin and S2 on the positive y values. A listener is located at the horizontal x axis 3.75 m from S1. The interference of the two sound waves emitted by S1 and S2 result in a transmitted frequency swept through the audible range (20 Hz to 20 kHz). The speed of sound in air is 343 m/s.

a) What are the lowest $f_{min,1}$ and second lowest $f_{min,2}$ frequencies that give minimum signal at the listener's location?

b) What are the lowest $f_{max,1}$ and second lowest $f_{max,2}$ frequencies that give maximum signal at the listener's location?

a) $\phi = (2m+1)\pi$

$\phi = 2\pi \frac{\Delta L}{\lambda}$ since $\lambda = \frac{v}{f}$

$\Rightarrow f = \frac{(m+\frac{1}{2})v}{\Delta L}$ $m: (0, 1, 2 \ldots)$

$f_{min_1} = \frac{v}{2\Delta L} = \frac{343}{2(-3.75 + \sqrt{3.75^2+4})} = 343\ Hz$ ($\sqrt{3.75^2+4} = 4.25$)

$f_{min_2} = \frac{3v}{2(\Delta L)} = 3 f_{min_1} = 1029\ Hz$

10 pts

b) $\phi = m 2\pi$

$\frac{\Delta L}{\lambda} = m$

$m (1, 2, 3 \ldots)$

$\Rightarrow f = \frac{mv}{\Delta L}$

$f_{max_1} = \frac{v}{0.5} = 686\ Hz$

$f_{max_2} = \frac{2v}{0.5} = 2 f_{max_1} = 1372\ Hz$

10 pts

Problem 1

The scale of a spring balance that reads from 0 to 15.0 kg is 12.0 cm long (i.e., the maximum displacement of the simple harmonic motion is 12 cm, when the balance reads 15.0 kg). A package suspended from the balance is found to oscillate vertically with a frequency of 2.00Hz.

a. What is the spring constant?
b. What is the mass of the package and how much does it weigh?

a) $w = \sqrt{\frac{k}{m}}$

$(2\pi f)^2 = \frac{k}{m} \Rightarrow k = m(2\pi f)^2$

$mg = kx$

$x = x_m \cos(wt + \phi)$

$\Rightarrow k = \frac{mg}{x} = $

$\Rightarrow k = 1226.25 \, N/m$

10 pts

b)

$T = 2\pi \sqrt{\frac{m}{k}}$ $T = \frac{1}{f} = 0.5$

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$\Rightarrow 2\pi f = \sqrt{\frac{k}{m}}$

$\Rightarrow m = \frac{k}{(2\pi f)^2}$

$0.5^2 = 4\pi^2 \frac{k}{m}$

$\Rightarrow m = \frac{4\pi^2 k}{0.5}$

$\Rightarrow m = 7.64 \, kg$

PART I

1. A small loudspeaker driven by an audio oscillator and amplifier is adjustable in frequency between 500 Hz and 1000 Hz sends sound waves into a cylindrical tube 1.0 m long and closed at both ends. The speed of sound in air is 343 m/s. At what frequencies will resonance occur in the pipe when the frequency emitted by the speaker is varied from 500 to 1000 Hz?
   - a. 514.5 Hz
   - b. 343 Hz
   - c. 1029 Hz
   - d. 171.5 Hz
   - e. None of the above, my answer is __________

   6pts

   $m = 3, 4, 5$

   $500 < \frac{mV}{2L} < 1000$

   $500 < m\,171.5 < 1000 \Rightarrow 2.91$

   $m(1, 2, 3$

   $\Rightarrow$ for $m = 3 \Rightarrow f = 514.5$ Hz

2. A sound wave has a frequency of 610 Hz and travels in air at a speed of 346 m/sec. How far apart are any two adjacent wave compressions?
   - a. 0.57 m
   - b. 9.40 m
   - c. 1.14 m
   - d. 1.75 m
   - e. None of the above, my answer is __________

   6pts

   $v = \lambda f \Rightarrow \lambda = \frac{v}{f} = 0.57\ m$

3. A loudspeaker produces a musical sound by means of the oscillation of a diaphragm. If the amplitude of oscillation is limited to 1.0×10^{-3} mm, what frequencies will result in the magnitude of the diaphragm's acceleration exceeding g? g=9.8 m/s^2
   - a. 50 Hz
   - b. 500 Hz
   - c. 100 Hz
   - d. 1000 Hz
   - e. None of the above, my answer is 883.5 Hz

   $a = -w^2 y_m = -(2\pi f)^2 y_m$

   $g = 4\pi^2 f^2\, 10^{-3} \times 10^{-3} \Rightarrow f = \sqrt{\ldots}$

4. The end of one of the prongs of a tuning fork that executes simple harmonic motion of frequency 1000Hz has an amplitude of 0.40mm. The speed of the end of the prong when the end has a displacement of 0.20mm is:

   a. ±2.5 m/s
   b. ±2.2 m/s
   c. 2.2 m/s
   d. 2.5 m/s
   e. None of the above, my answer is____________

5. A particle has a displacement $x = 0.5\cos\left(3t + \frac{\pi}{4}\right)$, where x is in meters and t is in seconds. At what time does the maximum velocity occur for the second time?

   a. 1.31 s
   b. 2.09 s
   c. 2.37 s
   d. 3.40 s
   e. None of above, my answer is ____________

6. A commuter train passes a passenger platform at a constant speed of 0.040 km/s. The train horn is sounded at its characteristic frequency of 320 Hz. The change in frequency detected by a person on the platform as the train passes is:

   a. 362.24 Hz
   b. 1.132 Hz
   c. 362.24 cycles/h
   d. 320.04 Hz
   e. None of the above, my answer is ____________

7. A search ship equipped with Sonar technology detects a sunken submarine 12 seconds after the first signal was emitted from the sonar exactly when the ship was above the submarine. Considering that speed of sound in seawater is 1522 m/s, the depth at which the submarine has sunken is:

   a. 18264 m
   b. 9132 m
   c. 17 km
   d. 10 km
   e. None of the above, my answer is ____________

8. A source emits 10^{-4} W/m² of sound isotropically. A small microphone located at 100 m from the source intercepts the sound in an area of 0.500 cm². The power of sound at the microphone's location is:

a. 5 nW

b. 13 kW

c. 12.57 W

d. 5 W

e. None of the above, my answer is ________

9. In certain ranges of piano keyboard, more than one string is tuned to the same note to provide extra loudness. For instance, the note at 110 Hz has two strings (with the same mass per unit length μ) that vibrate at this frequency. If one string slips from its normal tension of 600 N to 540 N, and if λ is the same on both strings, the beat frequency heard when the hammer strikes the two strings simultaneously is:

a. 8 beats/s

b. 8 cycles/s

c. 104.36 Hz

d. 5.64 Hz

e. None of the above, my answer is ________

10. A jet plane passes over you at a height of 5000 m and a speed of Mach 1.5. After the jet passes directly overhead, the time taken by the shock wave to reach you is (use 331 m/s for the speed of sound):

a. 16 s

b. 16.78 s

c. 22.58 s

d. 15.05 s

e. None of the above, my answer is ________