Midterm 1

Please note the questions below can be edited and changed by your instructor. The printed version is NOT guaranteed to match the online version at a later stage.

Homework Questions

Q1

(1 points)

A fictional character runs off a cliff, realizes his predicament, and lets out a scream. He continues to scream as he falls. If the physical situation is portrayed correctly, from the vantage point of an observer at the *bottom* of the cliff, the pitch of the scream as he falls should be ...

Select the correct answer

- higher than the original pitch and constant.
- lower than the original pitch and decreasing as he falls.
- higher than the original pitch and increasing as he falls.
- lower than the original pitch and constant.
- It is impossible to predict.

Q2

(1 points)

An organ pipe of length L that is open at one end resonates in its third harmonic with a wavelength of $4L/3$. Is the other end of the pipe closed or open?

Select the correct answer

- closed
- We cannot tell from the information provided.
- open

Q3

This question contains multiple parts. Make sure to read all the instructions and answer each part.

Two identical tuning forks resonate at 440 Hz (while at rest). Take the speed of sound as 340 m/s.

Part a

(1 points)

Suppose one of the tuning forks is moving away from you at 6.87 m/s. What is the frequency that you will experience from this tuning fork?

Select the correct answer

- 129 Hz
- 223 Hz
- 431 Hz
- 56.7 Hz
- 45.5 Hz

Part b

(1 points)

If you hold and listen to one of the tuning forks in front of your face (at rest) while also listening to the second tuning fork which is moving away from you at 6.87 m/s as in part a), what is the beat frequency you will hear?

Select the correct answer

- 9.89 Hz
- 6.53 Hz
- 8.71 Hz
- 4.40 Hz
- 12.5 Hz

Q4

This question contains multiple parts. Make sure to read all the instructions and answer each part.

An air column is 96.9 cm long and has a mass of 2.96 kg. It is open at the end nearest to the tuning fork and closed at the far end. Take the speed of sound as 340 m/s.

Part a

(1 points)

What is the fundamental frequency of the air column?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

Part b

(1 points)

What is the resonant frequency of the 7th harmonic for this air column?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

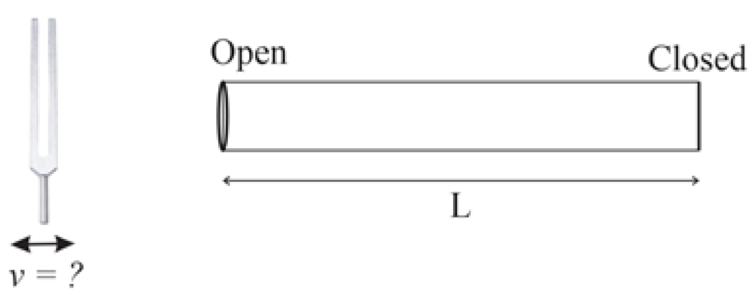
Part c

(1 points)

A tuning fork emits a constant pitch sound with a frequency of 590 Hz is brought in front of the open end of the air column. Suppose we want the tuning fork to resonate the 7th harmonic of the air column. The tuning fork on its own emits the wrong frequency sound, but we can use the doppler effect to change the frequency that the air column will "hear" and force it to resonate.

In which direction, towards or away, must the tuning fork move to resonate the air column in its 7th harmonic (keeping the air column stationary)?

Image size: s M L Max



Select the correct answer

Select the correct answer.

○ Towards

○ Away

Part d

(1 points)

How fast must the tuning fork move to resonate the air column in its 7th harmonic (keeping the air column stationary)?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

Part e

(1 points)

How long is the wavelength of the 7^{th} harmonic?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

Q5

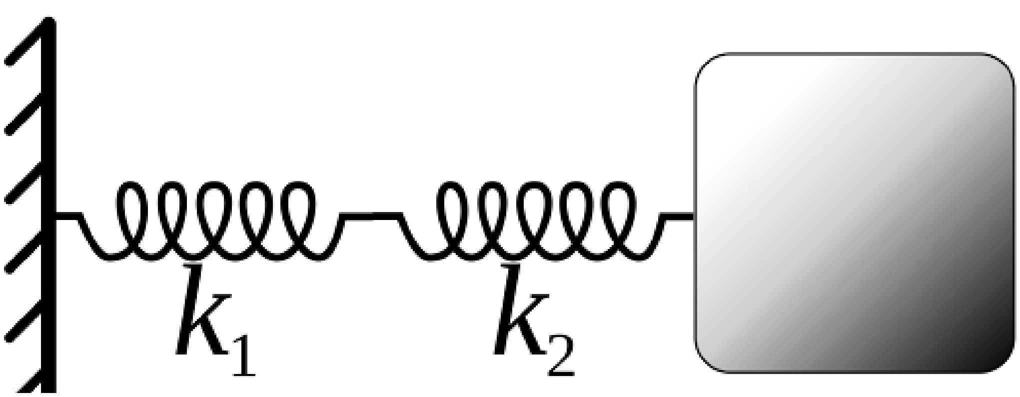
This question contains multiple parts. Make sure to read all the instructions and answer each part.

Two springs with spring constants k_1 and k_2 are attached to a wall and a block of mass m as shown in the figure. The mass-spring system is displaced a distance x from equilibrium and released from rest. In this configuration, the two springs together act together to obey Hooke's Law with a "equivalent spring constant" that obeys the relationship,

$$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}$$

(Hint: You can ignore gravity assume the only forces on the block are from the two springs.)

Image size: s M L Max



Part a

(1 points)

Let k_1 = 3.96 N/m, k_2 = 4.26 N/m, the mass of the block is m = 0.207 kg and the initial displacement of the system is x = 1.49 m.

What is the period of oscillation?

Select the correct answer

- 3.85 s
- 2.32 s
- 2.00 s
- 2.56 s
- 2.94 s

Part b

(1 points)

Let k_1 = 3.96 N/m, k_2 = 4.26 N/m, the mass of the block is m = 0.207 kg and the initial displacement of the system is x = 1.49 m.

Suppose we add a damping force $f = -bv$ to the system, where v is the velocity of the system and b=0.0798 Ns/m is the damping coefficient. Calculate the ratio of the initial energy stored in the resonator to the energy lost in one period of oscillation, e.g., $\frac{E_o}{\triangle E}$.

[Hint: You may find the following approximation (Taylor expansion) appropriate and useful: $e^x \approx 1 + x$, for $x \ll 1$.]

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

Part c

(1 points)

Let k_1 = 3.96 N/m, k_2 = 4.26 N/m, the mass of the block is m = 0.207 kg and the initial displacement of the system is x = 1.49 m.

Suppose the damped oscillator is now driven with a sinusoidal force, $F(t) = F_o cos(\omega t)$, where $F_o =$ 6.87 N is the maximum amplitude of the driving force and ω is the driving frequency.

You may recall the formula for the amplitude depends on the driving frequency:

$$A = \frac{F_0}{\sqrt{m^2(\omega^2 - \omega_0^2)^2 + b^2\omega^2}}.$$

What is the amplitude A of the system when driven at resonance, i.e., when $\omega = \omega_o$?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8