**A diagram of a line with a blue arrow

Description automatically generatedChapter 01: Wave**

**1. Vibration**

1. Calculate the period of a meter stick that is pivoted about one end and is oscillating in a vertical plane.
2. A diagram of a sphere and a ball

   Description automatically generatedThe two pendulums shown in the figure each consist of a uniform solid ball of mass M supported by a massless string, but the ball for pendulum A is very tiny while the ball for pendulum B is much larger. Find the period of each pendulum for small displacements. Which ball takes longer to complete a swing?
3. A 2.20-kg mass oscillates on a spring of force constant 250.0 N/m with a period of 0.615 s. Is this system damped or not? If it is damped, find the damping constant.
4. A 50.0-g object moves on the end of a spring with force constant *k* = 25.0 N/m. Its initial displacement is 0.300 m. A damping force *F* = - *bv* acts on the object, and the amplitude of the motion decreases to 0.100 m in 5.00 s. Calculate the magnitude of the damping constant *b*.

**2. Mechanical Wave**

1. A uniform cord has a mass of 0.300 kg and a length of 6.00 m. The cord passes over a pulley and supports a 2.00-kg object.

A diagram of a device attached to a wall

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1. Find the speed of a pulse traveling along this cord

2. Find the time it takes the pulse to travel from the wall to the pulley.

1. A wave pulse moving to the right along the *x* axis is represented by the wave function A black background with a black square

   Description automatically generated with medium confidence where *x* and *y* are measured in centimeters and *t* is measured in seconds. Plot the wave function at *t* = 0 and *t* = 1.0 s

**3. Superposition and Interference**

1. A pair of speakers placed 3.00 m apart are driven by the same oscillator. A listener is originally at point *O*, which is located 8.00 m from the center of the line connecting the two speakers.

A diagram of a plane

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**1.** The listener then walks to point *P*, which is a perpendicular distance 0.350 m from *O*, before reaching the *first minimum* in sound intensity. What is the frequency of the oscillator?

**2.** If the oscillator frequency is adjusted such that the first location at which a listener hears no sound is at a distance of 0.75 m from *O*, what is the new frequency?

1. Two small loudspeakers, A and B, are driven by the same amplifier and emit pure sinusoidal waves in phase. If the speed of sound is 350 m/s,

A diagram of a rectangular object with a keyhole and a rectangular object with a keyhole and a rectangular object with a keyhole and a rectangular object with a keyhole and a rectangular object with

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**(a)** for what frequencies does constructive interference occur at point P?

**(b)** For what frequencies does destructive interference occur at point P?

1. Two identical loudspeakers are located at points A and B, 2.00 m apart. The loudspeakers are driven by the same amplifier and produce sound waves with a frequency of 784 Hz. Take the speed of sound in air to be 344 m/s. A small microphone is moved out from point B along a line perpendicular to the line connecting A and B (line BC).

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**(a)** At what distances from B will there be destructive interference?

**(b)** At what distances from B will there be constructive interference?

**(c)** If the frequency is made low enough, there will be no positions along the line BC at which destructive interference occurs. How low must the frequency be for this to be the case?

**4/ STANDING WAVES**

1. Middle C on a piano has a fundamental frequency of 262 Hz, and the first A above middle C has a fundamental frequency of 440 Hz.

**(a)** Calculate the frequencies of the next two harmonics of the C string.

**(b)** If the A and C strings have the same linear mass density and

length *L*, determine the ratio of tensions in the two strings.

1. The high E string on a guitar measures 64.0 cm in length and has a fundamental frequency of 330 Hz. By pressing down on it at the first fret, the string is shortened so that it plays an F note that has a frequency of 350 Hz. How far is the fret from the neck end of the string?
2. A section of drainage culvert 1.23 m in length makes a howling noise when the wind blows.

**(a)** Determine the frequencies of the first three harmonics of the culvert if it is open at both ends. Take 343 m/s as the speed of sound in air.

**(b)** What are the three lowest natural frequencies of the culvert if it is blocked at one end?

**(c)** For the culvert open at both ends, how many of the harmonics present fall within the normal human hearing range (20 to 17 000 Hz)?

**7/ Sound Waves**

1. A point source emits sound waves with an average power output of 80.0 W. (a) Find the intensity 3.00 m from the source.

(b) Find the distance at which the sound level is 40 dB.

1. (a) By what factor must the sound intensity be increased to raise the sound intensity level by 13.0 dB?

(b) Explain why you don't need to know the original sound intensity.

**8/ Exercises**

1. Two identical machines are positioned the same distance from a worker. The intensity of sound delivered by each machine at the location of the worker is 2.0 × 107 W/m2. Find the sound level heard by the worker

**(a)** when one machine is operating and

**(b)** when both machines are operating

1. As an ambulance travels east down a highway at a speed of 33.5 m/s, its siren emits sound at a frequency of 400 Hz. What frequency is heard by a person in a car traveling west at 24.6 m/s?

a) as the car approaches the ambulance and

b) as the car moves away from the ambulance?

1. The police car with its 300-Hz siren is moving toward a warehouse at 30 m/s, intending to crash through the door. What frequency does the driver of the police car hear reflected front the warehouse?

**1/ The Nature of Light**