

Physics 11

Waves Unit Test Solutions

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1. Problem

Which unit is used to measure frequency?

- a. seconds per metre (s/m)
- b. metre (m)
- c. metres per second (m/s)
- d. hertz (Hz)

Solution

Frequency can be measured in units of hertz (Hz)

2. Problem

The shortest distance between two points on a wave where the wave pattern is repeated is the

- a. wavelength
- b. wave pulse
- c. frequency
- d. period

Solution

The wavelength is the shortest distance between two points on a wave where the wave pattern is repeated.

3. Problem

When waves spread out around the edge of a barrier, _____ occurs.

- a. interference
- b. diffraction
- c. rarefaction
- d. resonance

Solution

Diffraction occurs when waves spread out around the edge of a barrier.

4. Problem

In a standing wave on a string, nodes are points where

- a. maximum displacement occurs
- b. no displacement occurs
- c. energy is lost
- d. the wave is reflected

Solution

Nodes are where no displacement occurs.

5. Problem

When a wave enters a medium in which its speed increases, which change must occur?

- a. frequency increases
- b. frequency decreases
- c. wavelength increases
- d. wavelength decreases

Solution

When the speed increases across a boundary between two media, the frequency remains the same while the wavelength increases.

6. Problem

What does the speed of a mechanical wave depend on? **Select all that apply.**

- a. amplitude
- b. energy of the wave
- c. properties of the medium
- d. frequency

Solution

The speed of a mechanical wave depends only on the properties of the medium (temperature, density, tension, viscosity, stiffness, etc.)

7. Problem

Which of the following does **not** describe the pitch of a sound?

- a. loud or soft
- b. high or low
- c. frequency of vibration
- d. a musical note

Solution

Pitch can be described using a frequency, a musical note, or as high or low. It is not described by loud or soft (that is amplitude).

8. Problem

A wave travels from a more-dense medium into a less-dense medium. Which quantities must be greater for the transmitted wave than for the incident wave? **Select all that apply.**

- a. frequency
- b. period
- c. wavelength
- d. speed

Solution

When moving from a more dense medium to a less dense one, the speed and the wavelength are greater for the transmitted wave than the incident wave. The frequency and the period remain the same.

9. Problem

When a wave travels from one medium to another, which properties must be the same for both the incident and transmitted waves? **Select all that apply.**

- a. frequency
- b. wavelength
- c. period
- d. speed

Solution

The frequency and the period are the same for both the incident and transmitted waves.

10. Problem

A 195 Hz pure tone is played at the same time as a 785 Hz pure tone. What beat frequency will be produced?

- a. 332 Hz
- b. 738 Hz
- c. 590 Hz
- d. 798 Hz

Solution

The beat frequency is

$$f_{beat} = |f_2 - f_1| = |195 \text{ Hz} - 785 \text{ Hz}| = 590 \text{ Hz}$$

11. Problem

A student has two tuning forks, one with a frequency of 130 Hz and the other with frequency unknown. When struck together, the tuning forks produce 18 beats per second. What are the possible frequencies of the unknown tuning fork? **Select all that apply.**

- a. 7 Hz
- b. 148 Hz
- c. 94 Hz
- d. 166 Hz

Solution

The beat frequency is $f_{beat} = |f_2 - f_1|$ Therefore, the two possible frequencies are

$$f_1 - f_{beat} = 112 \text{ Hz}$$

and

$$f_1 + f_{beat} = 148 \text{ Hz}$$

12. Problem

What is the decibel level of a sound that has an intensity of $3.1 \times 10^{-3} \text{ W/m}^2$?

- a. 95 dB
- b. 65 dB
- c. 84 dB
- d. 52 dB

Solution

The decibel level is

$$10 \cdot \log_{10} \left(\frac{3.1 \times 10^{-3}}{1 \times 10^{-12}} \right) = 95 \text{ dB}$$

13. Problem

What is the intensity of a 77 dB sound?

- a. $1.12\text{E-}04 \text{ W/m}^2$
- b. $5.01\text{E-}05 \text{ W/m}^2$
- c. $1.15\text{E-}04 \text{ W/m}^2$
- d. $2.51\text{E-}05 \text{ W/m}^2$

Solution

The intensity of the sound is

$$10^{7.7-12} = 5.012\text{E} - 05 \text{ W/m}^2$$

14. Problem

How many times more intense is a 105 dB sound than a 80 dB sound?

- a. 203
- b. 320
- c. 248
- d. 119

Solution

The relative intensity of the sound is

$$I_2/I_1 = 10^{10.5-8} = 320$$

15. Problem

A sonar signal (sound wave) is emitted from a submarine and returns 0.0826 s later. The speed of sound in water is 1413 m/s. How far away is the object that reflected the sonar signal?

- a. 29.4 m
- b. 117 m
- c. 36.8 m
- d. 58.4 m

Solution

The distance to the object is half the distance traveled by the sonar signal because the sonar had to go there and back.

$$d = vt/2 = (1413 \text{ m/s})(0.0826 \text{ s})/2 = 58.4 \text{ m}$$

16. Problem

A parked car emits an alarm sound with a frequency of 1146 Hz. If the speed of sound in air is 354 m/s, what frequency will an observer hear while driving away from the parked car at a speed of 18 m/s?

- a. 1400 Hz
- b. 566 Hz
- c. 913 Hz
- d. 1090 Hz

Solution

The doppler shifted frequency for a receding observer is

$$f_{obs} = f_{source}(1 - v_{source}/v_{sound}) = 1088 \text{ Hz}$$

17. Problem

A car horn emits a frequency of 422 Hz when the car is stationary. If the speed of sound in air is 330 m/s, what frequency will an observer hear as the car is approaching at a speed of 30 m/s while the horn is sounding?

- a. 397 Hz
- b. 519 Hz
- c. 464 Hz
- d. 654 Hz

Solution

The doppler shifted frequency for an approaching source is

$$f_{obs} = \frac{f_{source}}{1 - v_{source}/v_{sound}} = 464 \text{ Hz}$$

18. Problem

What frequency is a major sixth above 484 Hz?

- a. 510 Hz
- b. 720 Hz
- c. 807 Hz
- d. 410 Hz

Solution

The frequency is

$$(1.6666667)(484 \text{ Hz}) = 807 \text{ Hz}$$

19. Problem

What frequency is 4 semitones above 852 Hz?

- a. 851 Hz
- b. 1073 Hz
- c. 722 Hz
- d. 546 Hz

Solution

The frequency is

$$(852 \text{ Hz}) \times 2^{4/12} = 1073 \text{ Hz}$$

20. Problem

A wave has a period of 7.92 seconds. What is its frequency?

- a. 0.173 Hz
- b. 0.14 Hz
- c. 0.126 Hz
- d. 0.113 Hz

Solution

Frequency is the reciprocal of the period. Therefore,

$$f = \frac{1}{T} = \frac{1}{7.92 \text{ s}} = 0.126 \text{ Hz}$$

21. Problem

A wave has a wavelength of 63 cm and a frequency of 20 Hz. What is its speed?

- a. 1260 m/s
- b. 12.6 m/s
- c. 9.9 m/s
- d. 8.07 m/s

Solution

Wave speed is wavelength times frequency. Remember to convert to SI base units (metres)

$$v = \lambda f = (0.63 \text{ m})(20 \text{ Hz}) = 12.6 \text{ m/s}$$

22. Problem

A wave has a frequency of 23 Hz and a speed of 44 m/s. What is its wavelength?

- a. 1010 m
- b. 1.04 m
- c. 1.91 m
- d. 1.29 m

Solution

Wave speed is wavelength times frequency ($v = \lambda f$). Therefore,

$$\lambda = \frac{v}{f} = \frac{44 \text{ m/s}}{23 \text{ Hz}} = 1.91 \text{ m}$$

23. Problem

A tuning fork has a frequency of 400 Hz. The fork causes resonances in an air column spaced at 46.1 cm. What is the speed of the sound?

- a. 464 m/s
- b. 244 m/s
- c. 369 m/s
- d. 539 m/s

Solution

The spacing between resonances is half a wavelength. Therefore, the wavelength is

$$\lambda = 2(46.1 \text{ cm}) = 92.2 \text{ cm}$$

Speed is frequency times wavelength.

$$v = f\lambda = (400 \text{ Hz})(92.2 \text{ cm}) = 369 \text{ m/s}$$

24. Problem

One organ pipe has a length of 2.0 m. A second pipe should have a pitch one major seventh higher. The pipe should be how long?

- a. 1.07 m
- b. 0.711 m
- c. 1.42 m
- d. 0.828 m

Solution

The speed is the same in both pipes and both resonate at their fundamental frequency. Therefore,

frequency and wavelength are inversely proportional to each other. In order for the second pipe to play a higher sound, it must have a shorter length.

$$L = (2 \text{ m}) / (1.875) = 1.07 \text{ m}$$

25. Problem

What is the wavelength of harmonic number 1 in an open-pipe resonator of length 0.69 m?

- a. 1.61 m
- b. 1.02 m
- c. 1.39 m
- d. 1.81 m

Solution

The wavelength is

$$\lambda = \frac{2L}{n} = 1.39 \text{ m}$$