Physics 11
Waves Unit Test Solutions

	a.	b.	c.	d.
1.	X			
2.			X	
3.		X		
4.		X		
5.			X	
6.			X	
7.			X	
8.	X	X		
9.			X	X
10.	X			
11.	X	X		
12.				X
13.			X	
14.				X
15.	X			
16.				X
17.				X
18.		X		
19.			X	
20.		X		
21.				X
22.				X
23.			X	
24.	X			
25.		X		

1. **Problem**
   Which unit is used to measure frequency?

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

   Solution
   Frequency can be measured in units of hertz (Hz)

2. **Problem**
   The number of repeating cycles per second is the

   a. wave pulse
   b. amplitude
   c. frequency
   d. period

   Solution
   The frequency of a wave is the number of repeating cycles per second.

3. **Problem**
   When waves spread out around the edge of a barrier, ______ occurs.

   a. reflection
   b. diffraction
   c. interference
   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. frequency
   c. properties of the medium
   d. wavelength

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

   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. speed
   b. wavelength
   c. frequency
   d. period

   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. wavelength
   b. speed
   c. period
   d. frequency

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

10. **Problem**
    A 541 Hz pure tone is played at the same time as a 321 Hz pure tone. What beat frequency will be produced?

    a. 220 Hz
    b. 304 Hz
    c. 273 Hz
    d. 328 Hz

    Solution
    The beat frequency is

    $$f_{beat} = |f_2 - f_1| = |541\,\text{Hz} - 321\,\text{Hz}| = 220\,\text{Hz}$$

11. **Problem**
    A student has two tuning forks, one with a frequency of 728 Hz and the other with frequency unknown. When struck together, the tuning forks produce 4 beats per second. What are the possible frequencies of the unknown tuning fork? **Select all that apply**.

    a. 724 Hz
    b. 732 Hz
    c. 728 Hz
    d. 720 Hz

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

    $$f_1 - f_{beat} = 724\,\text{Hz}$$

    and

    $$f_1 + f_{beat} = 732\,\text{Hz}$$

12. **Problem**
What is the decibel level of a sound that has an intensity of $5.6 \times 10^{-1}\,\mathrm{W/m^2}$?

a. 142 dB
b. 175 dB
c. 154 dB
d. 117 dB

Solution
The decibel level is

$$10 \cdot \log_{10}\left(\frac{5.6 \times 10^{-1}}{1 \times 10^{-12}}\right) = 117\,\mathrm{dB}$$

13. **Problem**
What is the intensity of a 100 dB sound?

a. 2.14E-02 $\mathrm{W/m^2}$
b. 3.31E-02 $\mathrm{W/m^2}$
c. 1.00E-02 $\mathrm{W/m^2}$
d. 2.29E-03 $\mathrm{W/m^2}$

Solution
The intensity of the sound is

$$10^{10-12} = 1.000E - 02\,\mathrm{W/m^2}$$

14. **Problem**
How many times more intense is a 105 dB sound than a 80 dB sound?

a. 1.88E+03
b. 3.07E+04
c. 1.36E+03
d. 320

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 $0.14\,\mathrm{s}$ later. The speed of sound in water is $1406\,\mathrm{m/s}$. How far away is the object that reflected the sonar signal?

    a. $98.4\,\mathrm{m}$
    b. $131\,\mathrm{m}$
    c. $154\,\mathrm{m}$
    d. $66.2\,\mathrm{m}$

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

$$d = vt/2 = (1406\,\mathrm{m/s})(0.14\,\mathrm{s})/2 = 98.4\,\mathrm{m}$$

16. **Problem**
A parked car emits an alarm sound with a frequency of 2125 Hz. If the speed of sound in air is 337 m/s, what frequency will an observer hear while driving away from the parked car at a speed of 26 m/s?

    a. 1480 Hz
    b. 1120 Hz
    c. 1740 Hz
    d. 1960 Hz

    Solution
    The doppler shifted frequency for a receding observer is

$$f_{obs} = f_{source}(1 - v_{source}/v_{sound}) = 1961\,\mathrm{Hz}$$

17. **Problem**
A car horn emits a frequency of 455 Hz when the car is stationary. If the speed of sound in air is 339 m/s, what frequency will an observer hear as the car is approaching at a speed of 14 m/s while the horn is sounding?

    a. 312 Hz
    b. 256 Hz
    c. 422 Hz
    d. 475 Hz

    Solution
    The doppler shifted frequency for an approaching source is

$$f_{obs} = \frac{f_{source}}{1 - v_{source}/v_{sound}} = 475\,\mathrm{Hz}$$

18. **Problem**
    What frequency is a major second above 256 Hz?
    a. 257 Hz
    b. 288 Hz
    c. 382 Hz
    d. 346 Hz

    Solution
    The frequency is
    $$(1.125)(256\,\text{Hz}) = 288\,\text{Hz}$$

19. **Problem**
    What frequency is 10 semitones above 335 Hz?
    a. 827 Hz
    b. 894 Hz
    c. 597 Hz
    d. 728 Hz

    Solution
    The frequency is
    $$(335\,\text{Hz}) \times 2^{10/12} = 597\,\text{Hz}$$

20. **Problem**
    A wave has a frequency of $90.5\,\text{Hz}$. What is its period?
    a. $0.0123\,\text{s}$
    b. $0.011\,\text{s}$
    c. $0.0149\,\text{s}$
    d. $0.0164\,\text{s}$

    Solution
    Period is the reciprocal of the frequency Therefore,
    $$T = \frac{1}{f} = \frac{1}{90.5\,\text{Hz}} = 0.011\,\text{s}$$

21. **Problem**
    A wave has a wavelength of $18\,\text{cm}$ and a frequency of $60\,\text{Hz}$. What is its speed?
    a. $907\,\text{m/s}$
    b. $8.2\,\text{m/s}$
    c. $613\,\text{m/s}$
    d. $10.8\,\text{m/s}$

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

$$v = \lambda f = (0.18\,\text{m})(60\,\text{Hz}) = 10.8\,\text{m/s}$$

22. **Problem**
A wave has a wavelength of $32\,\text{m}$ and a speed of $72\,\text{m/s}$. What is its frequency?

    a. $0.444\,\text{Hz}$
    b. $2170\,\text{Hz}$
    c. $474\,\text{Hz}$
    d. $2.25\,\text{Hz}$

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

$$f = \frac{v}{\lambda} = \frac{72\,\text{m/s}}{32\,\text{m}} = 2.25\,\text{Hz}$$

23. **Problem**
A tuning fork has a frequency of 389 Hz. The fork causes resonances in an air column spaced at 49.8 cm. What is the speed of the sound?

    a. 257 m/s
    b. 344 m/s
    c. 387 m/s
    d. 200 m/s

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

$$\lambda = 2(49.8\,\text{cm}) = 99.6\,\text{cm}$$

Speed is frequency times wavelength.

$$v = f\lambda = (389\,\text{Hz})(99.6\,\text{cm}) = 387\,\text{m/s}$$

24. **Problem**
One organ pipe has a length of 2.0 m. A second pipe should have a pitch one perfect fifth higher. The pipe should be how long?

    a. 1.33 m
    b. 1.17 m
    c. 1.91 m
    d. 1.71 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.

$$L = (2\,\text{m})/(1.5) = 1.33\,\text{m}$$

25. **Problem**
    What is the wavelength of harmonic number 6 in an open-pipe resonator of length 1.06 m?

    a. 0.307 m
    b. 0.353 m
    c. 0.184 m
    d. 0.512 m

    Solution
    The wavelength is

$$\lambda = \frac{2L}{n} = 0.353\,\text{m}$$