Waves Review Sheet Solutions

1. answer: B
Amplitude is measured from "rest to crest" meaning from the equilibrium position to a crest (or a trough, but still positive). So the wave has amplitude 16/2 = 8 cm

2. answer: D
Wavelength is measured from "crest to crest", or any part of a periodic wave to the next corresponding part of the wave. So the wave has a wavelength of 12×2=24 cm.

3. answer: C
$$f = \frac{1}{T} \quad \Rightarrow \quad T = \frac{1}{f} = \frac{1}{20} = 0.05 \text{ s}$$

4. answer: D
$$v = \lambda f = (24)(20) = 480 \ \tfrac{\text{cm}}{\text{s}}$$
$$480 \ \tfrac{\text{cm}}{\text{s}} \times \tfrac{10^{-2} \text{ m}}{1 \text{ cm}} = 4.80 \ \tfrac{\text{m}}{\text{s}}$$

5. answer: D
Any wave is a transfer of energy without transfer of matter. A mechanical wave involves oscillations of matter, but no net transfer. An electromagnetic wave can exist without any matter in oscillation, yet still transfers energy.

6. answer: D
Point X will first move up as the crest moves past, then move down as the trough moves past, then up again to return to equilibrium.

7. answer: C
The slit width, a, determines the boundary of the interference pattern. The slit separation, d, determines the spacing between the discrete maxima. With larger slit separation there are more maxima because the angle θ to any maximum is decreased. In other words, $d \uparrow$, $\theta \downarrow$

8. answer: B

The slit width, a, is larger, so the boundary of the interference pattern is smaller. In other words, $a \uparrow$, $\theta \downarrow$

9. answer: B
Harmonics are what make each instrument sound unique. The intensity of each harmonic varies from one instrument to the next, analogous to how each recipe for cookies calls for similar ingredients but in different amounts for each recipe! Extra credit for chocolate chip?

10. answer: C
100 decibel level is 80 decibels above the 20 decibel level. Each 10 dB level equals 10 times as much intensity, so 80 dB is 10^8 greater intensity.
Honors Physics solution:
$$\beta_1 = 10\log\left(\frac{I_1}{I_0}\right) \quad 100 = 10\log\left(\frac{I}{10^{-12}}\right) \quad 10^{10} = \frac{I}{10^{-12}} \quad I_1 = 10^{-2}$$
$$\beta_2 = 10\log\left(\frac{I_2}{I_0}\right) = 20 = 10\log\left(\frac{I}{10^{-12}}\right) \quad 10^{2} = \frac{I}{10^{-12}} \quad I_2 = 10^{-10}$$
$$\frac{I_1}{I_2} = \frac{10^{-2}}{10^{-10}} = 10^8$$

11. answer: A
The reflected wave stays upright because it is an open-end reflection off a less dense medium. The reflected wave loses some amplitude but its wavelength and speed stay constant. The transmitted was has greater wavelength and speed in the less dense medium, and has more amplitude.

12. answer: D
An open pipe has a harmonic given by $f_n = nv/2L$
When the pipe is closed at one end by the cap the equation becomes $f_n = nv/4L$. The fundamental frequency will be halved because at the same harmonic, same length, and same wave speed, the equation is always half.

13. answer: A
$$580 \text{ nm} \times \frac{10^{-9} \text{ m}}{1 \text{ nm}} = 5.80 \times 10^{-7} \text{ m}$$
$$c = \lambda f \qquad 3 \times 10^8 = (5.80 \times 10^{-7}) f$$
$$f = 5.17 \times 10^{14} \text{ Hz}$$

14. answer: B
Sound frequency is determined by the source of the sound waves. As sound enters a new medium, is changes speed, wavelength, and amplitude.

15. answer: C
$$f_n = \frac{nv}{2L} = \frac{3(60)}{2(1.2)} = 75 \text{ Hz}$$

16. answer: B/C
Constructive interference occurs at a *maximum* on an interference pattern when waves arrive in phase. This happens when the path length difference is is an integer multiple of a wavelength. Destructive interference occurs at a *minimum* when waves arrive out of phase. This happens when the path length difference an odd multiple of a half wavelength.

17. answer: C
Electromagnetic waves can propagate through a vacuum (empty space), and when they do, all electromagnetic waves travel a speed 3×10^8 m/s.

18. answer: A
When waves pass through an opening that is comparable to the size of the wavelength, diffraction is observed. The plane wave fronts diffract through the gap in the barrier and become semicircular wave fronts.

19. answer: C
The car and the ambulance must be getting closer to each other to have a Doppler increased frequency. Answers A and B are possible, but not *only if* situations.

20. answer: D
A longitudinal wave has medium in vibration in the same, or parallel, direction of wave itself.

21. answer: C
Constructive interference is observed at a point where a crest from one source meets a crest from another source.

22. answer: A
The path from S_1 to B is 4λ (four wavelengths). The path from S_2 to B is 3λ. So path difference is 4λ – 3λ = 1λ.

23. answer: D
Only polarization cannot be exhibited by longitudinal waves because, by definition, when a wave is polarized it waves in only one transverse direction.

24. answer: C
Resonance occurs when a force vibration occurs at a natural frequency. The first tuning fork forces the second tuning fork into vibration since they both have the same natural frequency.

25. answer: D
By definition, coherent waves are all in phase. A laser generates coherent light waves.

26. answer: D
The diagram shows the conditions to produce a standing wave. Each periodic wave has the same frequency and amplitude, but moves in the opposite direction. Point P will have destructive interference at all times, so it represents a node.

27. answer: B
In a single slit interference pattern, the width of the central maximum depends directly on the wavelength, inversely on the wave frequency, and inversely on the slit width. It does not depend on wave amplitude.

28.

$$f_o = f_s\left(\frac{v \pm v_o}{v \mp v_s}\right) = 6000\left(\frac{345-20}{345-40}\right) = 6393 \text{ Hz}$$

$$f_o = f_s\left(\frac{v \pm v_o}{v \mp v_s}\right) = 6000\left(\frac{345+20}{345+40}\right) = 5688 \text{ Hz}$$

$$\Delta f_o = 6393 - 5688 = 705 \text{ Hz}$$

29.

$$f_o = f_s\left(\frac{v \pm v_o}{v \mp v_s}\right) \quad 9000 = 7500\left(\frac{345+v_o}{345-45}\right)$$

$$v_o = 15 \text{ m/s}$$

30.

$$d = \frac{1 \text{ cm}}{100 \text{ lines}} \times \frac{10^{-2} \text{ m}}{1 \text{ cm}} = 1.0 \times 10^{-4} \text{ m}$$

$$x = 12.6 \div 2 = 6.3 \text{ mm} \times \frac{10^{-3} \text{ m}}{1 \text{ mm}} = 6.3 \times 10^{-3} \text{ m}$$

$$\theta = \tan^{-1}\left(\frac{x}{L}\right) = \tan^{-1}\left(\frac{6.3 \times 10^{-3}}{0.40}\right) = 0.902^\circ$$

$$d \sin\theta = m\lambda \quad 1.0 \times 10^{-4} \sin .902^\circ = 3\lambda$$

$$\lambda = 5.25 \times 10^{-7} \text{ m} \quad (\text{using } \lambda = dx/mL \text{ ok too})$$

31.

a. $f_n = \frac{nv}{2L} \quad 300 = \frac{1(345)}{2L} \quad L = 0.575 \text{ m}$

b. $f_n = \frac{nv}{4L} \quad f_1 = \frac{1(345)}{4(0.575)} = 150 \text{ Hz}$

c. flute: $f_2 = \frac{2(345)}{2(0.575)} = 600 \text{ Hz}$

clarinet: $f_3 = \frac{3(345)}{4(0.575)} = 450 \text{ Hz}$

32.

a. $f_n = \frac{nv}{4L} \quad f_3 = \frac{3(345)}{4(2.6)} = 99.5 \text{ Hz}$

b. $f_n = \frac{nv}{4L} \quad f_5 = \frac{5(345)}{4(2.6)} = 166 \text{ Hz}$

33.

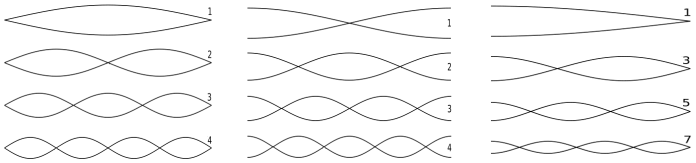
a. $486 \text{ nm} \times \frac{10^{-9} \text{ m}}{1 \text{ nm}} = 4.86 \times 10^{-7} \text{ m}$

$$d = \frac{m\lambda}{\sin\theta} = \frac{5(4.86 \times 10^{-7})}{\sin(4.60^\circ)} = 3.03 \times 10^{-5} \text{ m}$$

b. $d \sin\theta = \left(m + \frac{1}{2}\right)\lambda$

$$\theta = \sin^{-1}\left(\frac{\left(3+\frac{1}{2}\right)(4.86 \times 10^{-7})}{3.02 \times 10^{-5}}\right) = 3.22^\circ$$

34.



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35.

$$\mu = \frac{M}{L} = \frac{.0025}{1.2} = 0.00208 \text{ kg/m}$$

$$v = \sqrt{\frac{F_T}{\mu}} = \sqrt{\frac{100}{0.00208}} = 219 \text{ m/s}$$

$$f_n = \frac{nv}{2L} \quad f_3 = \frac{3(219)}{2(1.2)} = 274 \text{ Hz}$$

36.

$$\beta = 10 \log\left(\frac{I}{I_0}\right) \quad 95 = 10 \log\left(\frac{I}{10^{-12}}\right)$$

$$9.5 = \log\left(\frac{I}{10^{-12}}\right) \quad 10^{9.5} = 10^{\log\left(\frac{I}{10^{-12}}\right)}$$

$$I = 10^{-12} \times 10^{9.5} = 3.12 \times 10^{-3} \text{ W/m}^2$$

$$I = \frac{P}{4\pi r^2} \quad 3.16 \times 10^{-3} = \frac{6.0}{4\pi r^2} \Rightarrow r = 12.3 \text{ m}$$

37.

since $\theta < 5^\circ$, use $\frac{dx}{L} = m\lambda$

violet, 1st order: $\frac{(2 \times 10^{-5})x_1}{2} = 1(4 \times 10^{-7}) \Rightarrow x_1 = 0.04 \text{ m}$

red, 2nd order: $\frac{(2 \times 10^{-5})x_2}{2} = 2(6 \times 10^{-7}) \Rightarrow x_2 = 0.12 \text{ m}$

$$x_2 - x_1 = 0.12 - 0.04 \text{ m} = 0.08 \text{ m}$$

38.

a. $1150 \text{ nm} \times \frac{10^{-9} \text{ m}}{1 \text{ nm}} = 1.15 \times 10^{-6} \text{ m}$

$$a \sin\theta = m\lambda$$

$$a = \frac{m\lambda}{\sin\theta} = \frac{5(1.15 \times 10^{-6})}{\sin 6.2^\circ} = 5.32 \times 10^{-5} \text{ m}$$

b.

$$a \sin\theta = m\lambda$$

$$\lambda = \frac{a \sin\theta}{m} = \frac{(5.32 \times 10^{-5}) \sin 6.2^\circ}{9} = 6.39 \times 10^{-7} \text{ m}$$

$$6.39 \times 10^{-7} \text{ m} \times \frac{1 \text{ nm}}{10^{-9} \text{ m}} = 6.39 \times 10^{2} \text{ nm} = 639 \text{ nm}$$