Waves Review - Answer Key

Introduction to Waves

1. A wave is a transfer of energy through a medium without displacing the medium.

2. A transverse wave occurs when the motion of the medium is perpendicular to the direction the wave moves.
A longitudinal wave occurs when the motion of the medius is in the same direction the wave moves.

3. A transverse wave travels on water. (There are also longitudinal waves that travel on the surface).

4. ~~N/A~~ We did not discuss this in class. Don't worry about it!

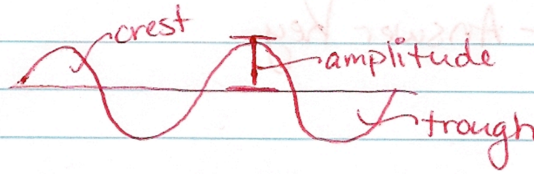
5. To produce a wave pulse in a slinky you can quickly move your hand from side to side OR forward and back (longitudinal).

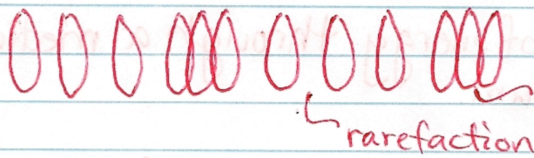
6. A wave pulse is a single crest or trough passing through the medium. A traveling wave is a continual passing of crests and troughs (or compressions and rarefactions).

Wave Terminology

7. Period: amount of time required to complete one wave cycle.
Frequency: amount of wave cycles seen in a given amount of time.
Amplitude: maximum displacement from rest position.
Wavelength: distance from crest to crest in one wave cycle.

8. Period and frequency are inverses of each other.
$T = 1/f$ OR $f = 1/T$

9. 

10. 

- the amplitude is distance from rest position. it is hard to show.

11. The amount of energy transferred determines the amplitude. more energy = larger amplitude; less energy = smaller amplitude

12. Same energy in a dense material will create a smaller amplitude than in a less dense medium. (harder to move it!)

13. $v = f\lambda$ or $v = d/t$

14. The velocity (or speed) of a wave depends on its medium, the frequency and wavelength.

Waves at Boundaries, Free End and Fixed End Reflection

15. Incident wave is the initial wave sent through a medium
Transmitted wave is the wave that occurs in the new medium
Reflected wave is the wave that "bounces back" in the original medium

16. Transmitted wave: upright, smaller amplitude
Reflected wave: inverted, smaller amplitude

17. Transmitted wave: upright, larger amplitude
Reflected wave: upright, smaller amplitude

18. Transmitted wave: upright, larger amplitude
Reflected wave: upright, smaller amplitude

19. Transmitted wave: upright, smaller amplitude
Reflected wave: inverted, smaller amplitude.

20. When the density of a medium changes at a boundary, the speed of the wave changes. A more dense medium will have a slower speed; a less dense medium will have a higher speed.

Superposition Principle

21. The superposition principle states that the resulting wave of any two interfering waves is the algebraic sum of the amplitudes of these waves.

22. When two waves meet on the same medium they pass through each other. This can be verified by passing two waves with a positive and negative amplitude through each other.

23. Constructive Interference is when two crests or two troughs meet to create a larger crest or trough.

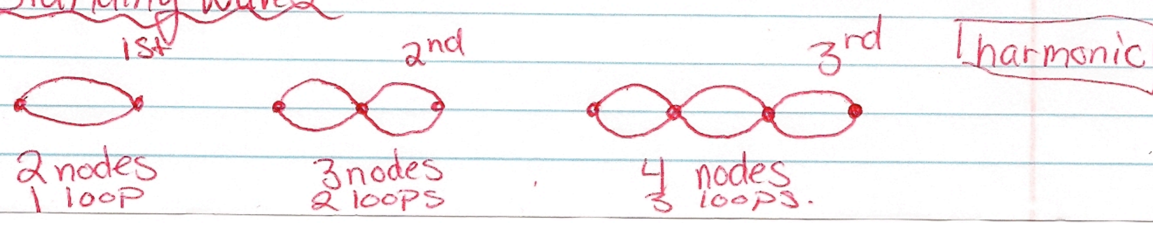
24. Destructive Interference is when a crest and a trough meet to create a smaller crest or trough.

25. Constructive interference occurs when the amplitude is greater than either of the crests or troughs.
Destructive interference occurs when the amplitude is less than the amplitudes of the crests or troughs.

26. Total Destructive Interference occurs when the crest and trough that meet have the same amplitude and completely cancel out while they overlap.

Standing Waves

27.
28.



29. A harmonic frequency is a frequency (or multiple of a frequency) that creates a standing wave.

30. A standing wave is formed when two waves with the same frequency interfere to create nodes that do not have displacement over time (TDI) and anti-nodes that fluctuate from crest to trough and back.

Diffraction and Refraction

31. Diffraction of a wave is the spreading out of a wave as it passes an obstacle.

32. A larger wavelength will experience more diffraction than a smaller wavelength.

33. A larger opening will create less diffraction than a smaller opening (at the same wavelength).

34. As waves pass through a barrier of two or more openings they will diffract around both openings and interfere creating nodal lines and anti-nodal lines.

35. Refraction of a wave is the bending of the wave's path as it passes from one medium to another medium.

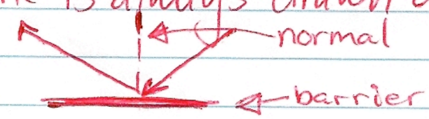
36. When a wave refracts the velocity (or speed) will change (faster in a less dense medium), the wavelength will change (larger in a less dense medium) but the frequency will stay the same.

Law of Reflection

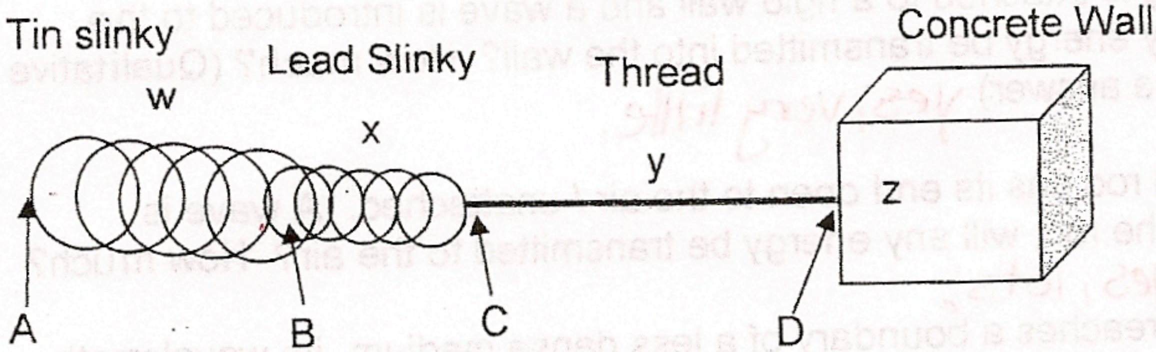
37. The law of reflection states that the angle of incidence will be the same as the angle of reflection

38. The incident wave is the original wave that strikes the barrier; the reflected wave is the wave that "bounces back" and leaves the barrier.

39. A normal line is always drawn at a right angle to the barrier.



Waves at Boundaries Review



A wave pulse travels right in a tin slinky as a crest;

a. As it moves right, will it be a crest or trough in:
   i. x crest
   ii. y crest
   iii. z crest

b. Will most of the Energy be reflected or transmitted at the following boundaries:
   i. B reflected
   ii. C transmitted
   iii. D reflected

c. Will the **reflected** wave be a crest or a trough in the following:
   iv. w trough
   v. x crest
   vi. y trough

d. Will the **velocity** change at the following boundaries:
   vii. B yes → slowdown
   viii. C yes → speed up
   ix. D yes → slowdown.

Waves at Boundaries Review

1. If a light spring is attached to a rigid wall and a wave is introduced to the spring, will any energy be transmitted into the wall? How much? (Qualitative not quantitative answer) yes; very little.

2. A dense metal rod has its end open to the air / unattached. A wave is introduced to the rod, will any energy be transmitted to the air? How much?
   yes, lots!

3. When a wave reaches a boundary of a less dense medium, its wavelength and velocity change but its frequency does not. Explain why.
   can move faster in less dense medium, crests appear at same rate, so wavelength must change to keep f constant.

4. When a wave with a frequency of 200 Hz transfers from a dense medium to a less dense medium:
   i. Will the transmitted wave be slower or faster? faster
   ii. What will the frequency of the wave in the less dense medium be? 200 Hz
   iii. Will the transmitted wave have an increased wavelength? Why or why not? yes => same frequency and faster speed means you must have a larger wavelength. $v = f\lambda$

5. A wave moves from water (density = 1.0 g/mL) to ketchup (density = 1.2 g/mL).
   i. How does the wavelength change? Smaller wavelength.
   ii. Will the wave be erect or inverted in the water? What about the transmitted wave into the ketchup? inverted; erect.
   iii. Will more energy be transmitted or reflected? reflected.

hysics 20 – Standing Waves Practice Name: Answer Key

. A student shakes the end of a 2.40 m long spring (the other end being attached to a wall.) The student shakes the spring at the frequency necessary to create a fourth harmonic standing wave.

a) How many nodes does the fourth harmonic standing wave have? **5**

b) How many loops does the fourth harmonic standing wave have? **4**

c) What is the wavelength of this standing wave? **1.20 m**

:. The student from question 1 changes their standing wave to the fifth harmonic, did the wavelength increase or decrease? Did the frequency they are shaking the spring at increase or decrease? **decrease; increase**

3. The student from question 1 varies the frequency again and a new standing wave with a wavelength of 1.60 m appears on the spring. Which harmonic does this new standing wave represent? **3rd**

$2.4\text{ m} \div 4 = 0.6\text{ m}$
$0.6 \times 3 = 1.8\text{ m}$.

4. The student in question 1 decides to make a standing wave with a wavelength of 1.25 m on the spring. Is this possible? Explain.
no, 1.20 m would give 2nd harmonic (0.6 m + 0.6 m).

5. A standing wave has 6 loops. Which harmonic does this represent? **6th**

6. A standing wave has 3 nodes. Which harmonic does this represent? **2nd**

7. A first harmonic standing wave is created when a 80.0 cm long metal rod is vibrated at 900 Hz. What is the speed of the wave through the rod? $V = f\lambda = (900\text{ Hz})(1.60\text{ m})$ **$V = 1440\text{ m/s}$**
$\frac{1}{2}\lambda = 80.0\text{ cm} \times \frac{1\text{ m}}{100\text{ cm}} = 0.800\text{ m} \times 2 = 1.60\text{ m}$

8. What frequency of vibration, when applied to the metal rod from question 7, would create a second harmonic standing wave? How does this frequency compare to the frequency that created a first harmonic standing wave?
2nd harmonic $= 2f = 2(900\text{ Hz}) =$ **1800 Hz**.

Bonus - Without using any equations, find the frequency of vibration that would create a fifth harmonic standing wave on the metal rod from questions 7 & 8. (The information and answers from questions 7 & 8 provide a clue.) $5f = 5(900\text{ Hz}) =$ **4500 Hz**.

Numerical Answers:

Try the question first. Use the answers to check if you are correct. If you peek before you try, you will learn a lot less.

1. a) 5
   b) 4
   c) 1.20 m

3. Third
5. Sixth
6. Second

7. 1440 m/s
8. 1800 Hz