Mechanical Waves Conceptual Survey (MWCS)

This survey is part of a project being undertaken by the Sydney University Physics Education Research Group (SUPER). Thank you for agreeing to take part in the survey; it should not take longer than 30 minutes to complete.

- Please write your answers on the line by the question numbers.

Participation in this project by completing this survey is completely voluntary. No information about individual answers or your identity will be given to people teaching or assessing the course.

Name: ________________________________________________________________

SID: __________________________________________________________________

Stream:  ☐ Advance  ☐ Regular  ☐ Fundamental

Gender:  ☐ Female  ☐ Male
1) Two students sing equally loudly. Student X sings at a high pitch, student Y sings at a lower pitch. Which of the following is true?

A. The two frequencies are the same, but the amplitudes are different.
B. The two amplitudes are the same, but the frequencies are different.
C. The two frequencies are the same, and the amplitudes are also the same.
D. The two frequencies are different, and the amplitudes are also different.

Consider the following description and answer questions 2 - 3.

Students X and Y are standing 50 meters apart and yell “Yo!” at each other at exactly the same time.

2) They yell at each other with the same loudness, but Y yells with a higher pitch than X does. Who will hear the other’s sound first?

A. They will hear each other at exactly the same time because the speed of sound waves depends on the properties of the air.
B. X will hear the sound first because the speed of sound waves depends on frequency according to $v = f \lambda$.
C. They will hear each other at exactly the same time because the speed of sound waves depends on amplitude.
D. X will hear the sound first because sound with a higher frequency is more penetrating.

3) Student Y yells louder than X, but they yell at each other with the same pitch. Who will hear the other’s sound first?

A. X will hear the sound first because the speed of the waves depends on the amplitude of the sound.
B. They will hear each other at exactly the same time because the speed of the waves depends on the frequency according to $v = f \lambda$.
C. They will hear each other at exactly the same time because the speed of the waves depends on the properties of the air.
D. X will hear the sound first because the wave with the larger amplitude travels further.
Consider the following description and answer questions 4 – 5.
One end of a long taut string is tied to a distant pole while the other end of the string is held by a girl (see figure below). This girl quickly flicks her hand up and down to create a pulse moving towards the pole.

___ 4) She now wants to produce a pulse that takes a shorter time to reach the pole. How can she do this?

A. Flick the string harder to push more force into the pulse.
B. Flick the string faster to create a pulse with higher frequency.
C. Flick the string further up and down to create a pulse with larger amplitude.
D. Flick the string a shorter distant up and down to create a pulse with smaller amplitude.
E. Wait until the first pulse is reflected back then flick again to add the pulses together.
F. None of the above would produce a pulse that takes a shorter time to reach the pole.

___ 5) She still wants the pulse to reach the pole in a shorter time by changing the properties of the string. How can she do this?

A. She should use a lighter string, under the same tension, because the velocity increases as the density decreases.
B. She should use a heavier string, under the same tension, because the velocity increases as the density increases.
C. She should decrease the tension in the string because the velocity increases as the tension decreases.
D. None of the above would produce a pulse that takes a shorter time because the speed is determined by frequency and wavelength according to \( v = f \lambda \).
Consider the following description and answer questions 6 - 8.
A dust particle hovers in front of a silent loudspeaker (see figure below). The loudspeaker is turned on and plays a loud tone at a constant pitch.

___ 6) How will the dust particle move?

A. It will stay in the same position.
B. It will move back and forth about the same position.
C. It will move up and down about the same position.
D. It will move away from the speaker.
E. It will move away as a sine curve.

For questions 7 and 8, choose the description from A through H which best answers each question.

A. It will stay at the same position.
B. It will move back and forth further.
C. It will move back and forth faster.
D. It will move up and down further.
E. It will move up and down faster.
F. It will move away further.
G. It will move away faster.
H. It will move away faster as a sine curve.

___ 7) The pitch of the sound is increased but the volume stays the same. What happens to the motion of the dust particle?

___ 8) The volume of the sound is increased but the pitch stays the same. What happens to the motion of the dust particle?
Consider the following description and answer questions 9-10.

Two pulses are moving towards each other. Each pulse has a speed of 1 cm/s. The figure on the right shows the pulses at time t = 0 s. Each square width corresponds to 1 cm x 1 cm. The dashed lines indicate the correct positions of the individual pulses after 2 s.

___ 9) Select the drawing that corresponds to the shape of the resultant pulse after 2 s.

A.  
B.  
C.  
D.  
E.  
F.  

___ 10) Select the drawing and explanation that corresponds to the shape of the resultant pulse after 5 s.

A. Waves have passed through one another and retained their shapes.  
B. Waves have become smaller because they have collided and so lost energy.  
C. Waves have cancelled each other.
Consider the following description and answer questions 11-12.

Two pulses are moving towards each other. Each pulse has a speed of 1 cm/s. The figure on the right shows the pulses at time $t = 0$ s. Each square width corresponds to 1 cm x 1 cm.

___ 11) Select the drawing that corresponds to the shape of the resultant pulse after 3 s.

A.  
B.  
C.  
D.  
E.  
F.  

___ 12) Select the drawing that corresponds to the shape of the resultant pulse after 5 s.

A. Waves have passed through one another and retained their shapes.
B. Waves have cancelled each other.
C. Waves become smaller because they have collided and so lost energy.
D. Waves have collided with each other and turned upside-down.
Consider the following description and answer questions 13-14.

A girl is demonstrating wave motion on a string attached to a pole. The string can be either firmly attached so that the end cannot move or tied to a ring that can move loosely up and down on the pole. The girl flicks the string creating an asymmetric pulse moving towards the pole. The pulse has a speed of 1 cm/s. Each square in the figure corresponds to 1 cm x 1 cm. The figure on the right shows the pulse at t = 0 s.

For questions 13 and 14, choose the drawing from A through E which best answers each question.

___ 13) Select the drawing that corresponds to the shape of the resultant pulse after 4 s, assuming the string is firmly attached to the pole.

___ 14) Select the drawing that corresponds to the shape of the resultant pulse after 4 s, assuming the string is tied to a ring that can move loosely up and down on the pole.
Consider the following description and answer questions 15-16.

A girl is demonstrating wave motion on a string attached to a pole. The string can be either firmly attached so that the end cannot move or tied to a ring that can move loosely up and down on the pole. The girl flicks the string creating a symmetric pulse moving towards the pole. The pulse has a speed of 1 cm/s. Each square in the figure corresponds to 1 cm x 1 cm. The figure on the right shows the pulse at t = 0 s.

___ 15) Select the drawing that corresponds to the shape of the resultant pulse after 2 s, assuming the string is firmly attached to the pole.

___ 16) Select the drawing that corresponds to the shape of the resultant pulse after 2 s, assuming the string is tied to a ring that can move loosely up and down on the pole.
Consider the following description and answer questions 17-19.

A standing wave is produced with a fixed length string, one end of which is attached to a vibrator, the other end of which is placed on a pulley and hung with a mass. Using the vibrator, the second harmonic standing wave is created (see figure below). The length between the vibrator and the pulley does not change.

17) If the frequency of the vibrator is doubled while everything else stays the same, a different harmonic standing wave is created. How would the wavelength of the new harmonic standing wave change?

___ Answer:
A. Increase
B. Decrease
C. Stay the same

___ Reason:
1. The wavelength depends on the amount of energy flowing in the waves.
2. The wavelength is proportional to frequency since the velocity doesn’t change.
3. The wavelength depends on the length of the rope the frequency doesn’t affect the wavelength.
4. The wavelength is inversely proportional to the frequency since the velocity doesn’t change.

18) If the mass is increased by a factor of four while everything else stays the same, a different harmonic standing wave is created. How would the wavelength of the new harmonic standing wave change?

___ Answer:
A. Increase
B. Decrease
C. Stay the same

___ Reason:
1. The wavelength depends only on the length of the rope.
2. The wavelength is inversely proportional to the frequency.
3. As the tension increases, the speed of the wave increases.
4. As the tension increases, it is harder to get the string to vibrate.
19) If a thicker (more mass) rope is used while everything else stays the same, a different harmonic standing wave is created. How would the wavelength of the new harmonic standing wave change?

**Answer:**
A. Increase  
B. Decrease  
C. Stay the same

**Reason:**
1. The wavelength depends only on the length of the rope.  
2. The wavelength is inversely proportional to the frequency.  
3. As the rope becomes heavier, the speed of the wave decreases.  
4. As the rope becomes heavier, the amount of energy flowing in the waves is different.

20) A tuning fork is hit and held in front of a one open-ended cylinder. The first harmonic resonance (the fundamental) is generated. Which diagram best describes the pattern of the displacement of air molecules inside the tube.

![Diagram of a tuning fork and an open-ended cylinder with options A to F]

A.  
B.  
C.  
D.  
E.  
F.
21) Two tubes have the same diameter and length. One has two open ends, and the other has only one open end. The fundamental frequencies of these two tubes are…

**Answer:**
A. the same  
B. greater in the tube with one open end  
C. greater in the tube with two open ends  

**Reasons:**
1. There is more air pressure in the tube with one open end.  
2. The two tubes contain the same number of air molecules.  
3. The two tubes have the same size and the ends do not matter.  
4. The wavelength in the tube with one open end is longer than in the other one.  
5. The wavelength in the tube with one open end is shorter than in the other one.

22) Air is blown across the top end of a bottle filled one third with water, creating a sound. How would the pitch of the sound be changed if more water were added to fill the bottle to half full? The pitch would…

**Answer:**
A. stay the same  
B. become higher  
C. become lower  

**Reasons:**
1. Each bottle has its own constant frequency.  
2. The air column becomes shorter and the wavelength changes.  
3. There is a shorter air column, so the air molecules have less space to vibrate.  
4. There is a shorter air column, so there is higher air pressure inside the bottle.  
5. There is a longer column of water which absorbs more energy from the sound waves.