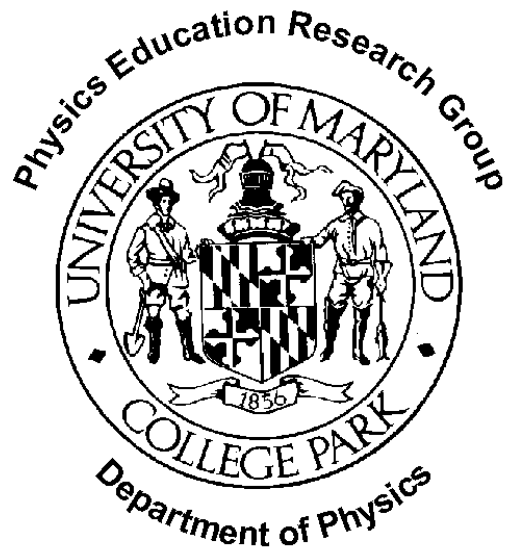

University of Maryland Wave Diagnostic Test



Department of Physics
University of Maryland,
College Park MD 20742-4111

<http://www.physics.umd.edu/rgroups/ripe/perg/>

Administering the UMd Wave Diagnostic Test

The University of Maryland (UMd) Wave Diagnostic Test has been designed to investigate student difficulties with wave physics at the introductory level. The Physics Education Research Group (PERG) at UMd has developed these questions through a research process that has included individual demonstration interviews, examination questions, and the administration and evaluation of curriculum materials (also included in this packet). For more information about the research into student understanding of waves and the Activity Based Physics project, see the PERG web site at <http://www.physics.umd.edu/rgroups/ripe/perg/>.

Time Required

The UMd Wave Diagnostic Test is designed to be administered as a pre- and post-instruction test. Two versions exist (one long, one short, as noted at the bottom right side of the first page of each). The same version should be used for both pre- and post-tests. We recommend that the test *not* be given in an exam or be graded for correctness, but that students be given credit for participating. Also, we suggest that the test not be returned to them (especially when asked before instruction) to prevent them (and future students) from studying to the test.

To administer the long version of the diagnostic test, students will need about 30 minutes. The short version can be administered in half that time. In both cases, students should do Part 1 of the test and turn it in before receiving Part 2 of the test. They should be sure to put their names on both parts, so that these can later be matched up.

Why Two Parts?

The UMd Wave Diagnostic Test comes in two parts. Part 1 of the test includes free response (FR) versions of two questions that students answer a second time in multiple-choice, multiple-response (MCMR) format in Part 2. The comparison of student responses on the FR and MCMR questions can lead to a richer understanding of the strength of student understanding of the material. The diagnostic test comes in two parts so that students cannot go back and alter their responses on the FR questions after they read the offered MCMR responses.

Participating in UMd Research

The UMd Wave Diagnostic Test has been developed as part of the Activity Based Physics project (NSF Grant DUE-9455561). PERG at UMd encourages you to share your students' results on the diagnostic test with us. By filling out the survey form on the following page and sending us copies of your students' responses, you would help us gain insight into student performance at a variety of schools and settings. The Wave Diagnostic Test (both versions) is printed in the following pages. We ask that you do not alter the questions in any way but communicate any comments you have to us. Please send all correspondence to

Edward F. Redish
Physics Department
University of Maryland
College Park, MD 20742-42111
Email: redish@physics.umd.edu

University of Maryland Wave Diagnostic Test Summary Sheet

Please fill out this form and return it with copies of the student Wave Diagnostic Tests from each delivery (i.e. pre or post instruction).

Institution _____

Date _____

Course _____

Instructor _____

Is the Wave Diagnostic Test being administered before instruction, after instruction, or both?

What wave physics topics were covered in class (if administered after instruction)?

Have students taken an exam whose topics include waves? If so, how long ago?

What level course is this (engineering/general/majors/algebra/calculus/etc.)?

Describe the type of instruction (lecture/recitation/lab/workshop/studio/tutorial/etc.).

Additional Comments:

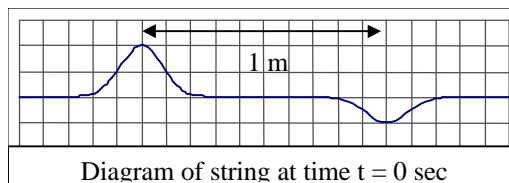
1. Michael and Laura are standing 100 m apart and yell “Yo!” at each other at exactly the same instant. Michael yells louder than Laura, and the pitch (frequency) of his voice is lower.

Will Laura hear Michael first, Michael hear Laura first, or will they hear each other at the same time? Explain how you arrived at your answer.

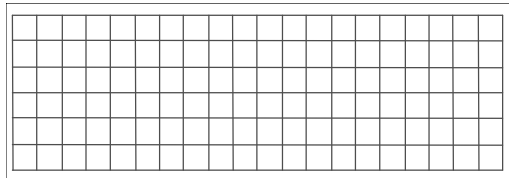
How, if at all, would your answer change if Laura yelled at the same volume as Michael? Explain your reasoning.

How, if at all, would your answer to the original question change if Michael and Laura yelled at the same pitch but Michael yelled louder? Explain your reasoning.

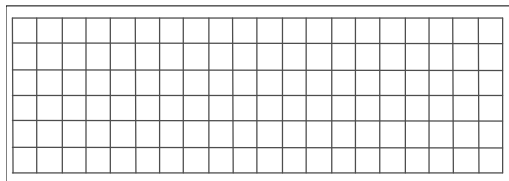
2. Consider two wavepulses with different amplitudes moving on a string at speed of 10 m/s toward each other. **At time $t = 0$ sec**, the shape of the string is shown in the diagram to the right, and the wavepulses are separated by a distance of 1 m.



Sketch the shape of the string at time $t = 0.05$ sec in the diagram to the right. Explain how you arrived at your answer.



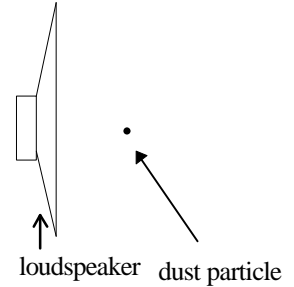
Sketch the shape of the string at time $t = 0.1$ sec in the diagram to the right. Explain how you arrived at your answer.



UMD Wave Diagnostic Test

3. A dust particle is located in front of a silent loudspeaker (see figure). The loudspeaker is turned on and plays a note at a constant pitch.

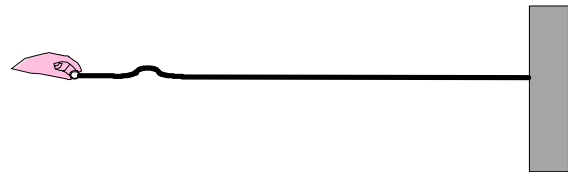
Describe the motion of the dust particle. Explain your reasoning.



How, if at all, would your answer change if the speaker played a note at a higher pitch (frequency)? Explain your reasoning.

How, if at all, would your answer to the original question change if the speaker played a note at a greater volume (but the original pitch)? Explain.

4. A person holds a long, taut string and quickly moves her hand up and down, creating a pulse which moves toward the wall to which the string is attached. The pulse reaches the wall in a time t_0 (see figure).

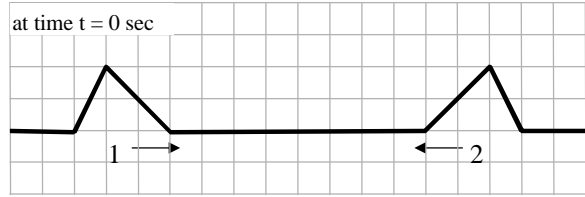


How could the person decrease the amount of time it takes for the pulse to reach the wall? Explain.

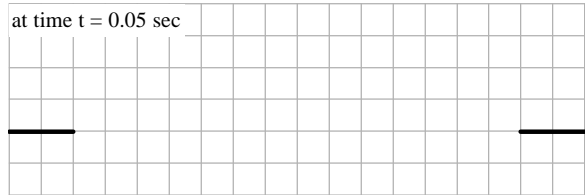
How, if at all, would the *speed* of the pulse change if the pulse were wider? Explain your reasoning.

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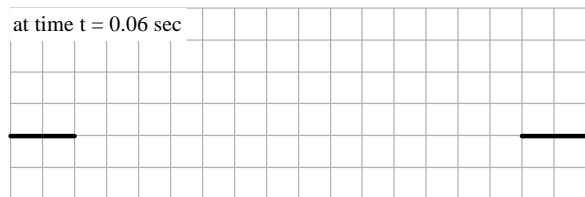
5. Consider two pulses on a spring, as shown in the figure to the right. They are moving toward each other at 100 cm/sec. Each block in the picture represents 1 cm.



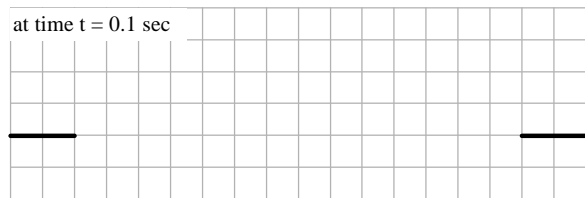
In the figure to the right, sketch the shape of the spring after 0.05 sec have elapsed. Explain how you arrived at your answer.



In the figure to the right, sketch the shape of the spring after 0.06 sec have elapsed. Explain how you arrived at your answer.



In the figure to the right, sketch the shape of the spring after 0.1 sec have elapsed. Explain how you arrived at your answer.



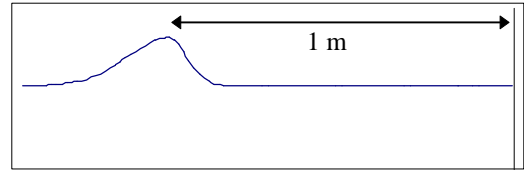
6. Margaret stands 20 m from a large wall and claps her hands together once. A short moment later, she hears an echo.

How, if at all, would the time it takes for her to hear the echo change if she clapped her hands harder? Explain.

Consider a dust particle floating in the air very close to the wall (within 0.1 mm). Describe the motion, if any, of this dust particle between the moment that Margaret claps and the moment she hears the echo. Explain how you arrived at your answer.

UMD Wave Diagnostic Test

7. An asymmetric wavepulse moves on a string toward a pole at speed 10 m/s. At time $t = 0$ sec, the shape of the string is shown in the diagram to the right and the peak of the wavepulse is a distance 1 m from the pole.



Consider that the string is **firmly attached** to the pole.

In the figure to the right, sketch the shape of the string at time $t = 0.1$ sec. Explain how you arrived at your answer.



In the figure to the right, sketch the shape of the string at time $t = 0.2$ sec. Explain how you arrived at your answer.



8. Consider that the experiment above (in question 7) is repeated, but the string shown in the figure is **free to move** along the pole to which it is attached.

In the figure to the right, sketch the shape of the string at time $t = 0.1$ sec. Explain how you arrived at your answer.

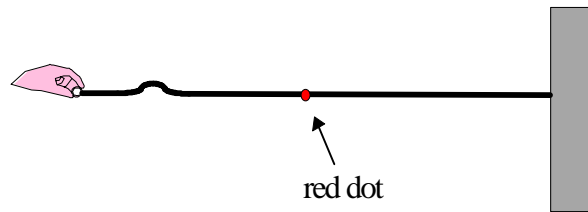


In the figure to the right, sketch the shape of the string at time $t = 0.2$ sec. Explain how you arrived at your answer.



**After completing these questions, please turn in this part of the questionnaire.
Then, get the last page of the questionnaire...**

9. A long, taut string is attached to a distant wall (see figure). A demonstrator moves her hand and creates a very small amplitude pulse which reaches the wall in a time t_0 . A small red dot is painted on the string halfway between the demonstrator's hand and the wall. For each question, state which of the actions *a–k* (listed to the right) **taken by itself** will produce the desired result. For each question, more than one answer may be correct. If so, **give them all**.



How, if at all, can the demonstrator repeat the original experiment to produce:

A pulse that takes a longer time to reach the wall. More than one answer may be correct. If so, **give them all**. _____ Explain.

A pulse that is wider than the original pulse. More than one answer may be correct. If so, **give them all**. _____ Explain.

A pulse that makes the red dot stay in motion for less time than in the original experiment. More than one answer may be correct. If so, **give them all**. _____ Explain.

A pulse that makes the red dot travel a further distance than in the original experiment. More than one answer may be correct. If so, **give them all**. _____ Explain.

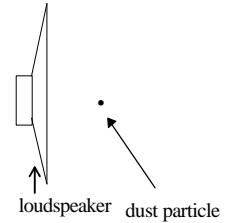
Possible responses for all parts of question 9:

- a) Move her hand more quickly (but still only up and down once and still by the same amount).
- b) Move her hand more slowly (but still only up and down once and still by the same amount).
- c) Move her hand a larger distance but up and down in the same amount of time.
- d) Move her hand a smaller distance but up and down in the same amount of time.
- e) Use a heavier string of the same length, under the same tension
- f) Use a lighter string of the same length, under the same tension
- g) Use a string of the same density, but decrease the tension.
- h) Use a string of the same density, but increase the tension.
- i) Put more force into the wave.
- j) Put less force into the wave.
- k) none of the above.

UMD Wave Diagnostic Test, part 2

10. A dust particle is located in front of a silent loudspeaker (see figure). The loudspeaker is turned on and plays a note at a constant (low) pitch. **Which choice or combination of the choices $a-f$ (listed below) can describe the motion of the dust particle after the loudspeaker is turned on?**

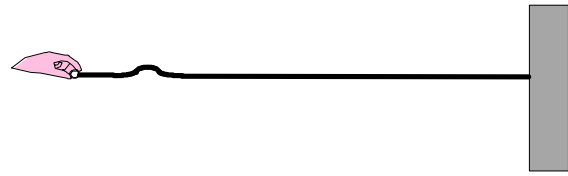
Circle the correct letter or letters. Explain.



Possible responses for question 10:

- a) The dust particle will move up and down.
- b) The dust particle will be pushed away from the speaker.
- c) The dust particle will move side to side.
- d) The dust particle will not move at all.
- e) The dust particle will move in a circular path.
- f) None of these answers is correct.

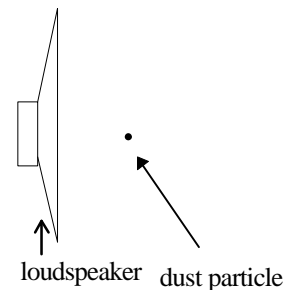
1. A person holds a long, taut string and quickly moves her hand up and down, creating a pulse which moves toward the wall to which the string is attached. The pulse reaches the wall in a time t_0 (see figure).



How could the person decrease the amount of time it takes for the pulse to reach the wall? Explain.

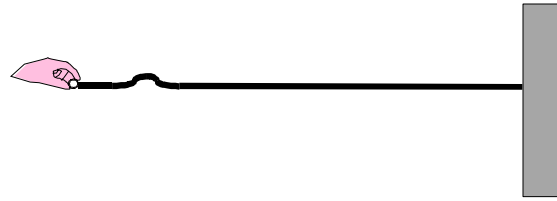
2. A dust particle is located in front of a silent loudspeaker (see figure). The loudspeaker is turned on and plays a note at a constant pitch.

Describe the motion of the dust particle. Explain your reasoning.



**After completing these questions, please turn in this part of the questionnaire.
Then, get the last page of the questionnaire...**

3. A long, taut string is attached to a distant wall (see figure). A demonstrator moves her hand up and down exactly once and creates a very small amplitude pulse which reaches the wall in a time t_0 . For the question below, state which of the actions $a-k$ (listed to the right) **taken by itself** will produce the desired result. Note that more than one answer may be correct. If so, **give them all**.

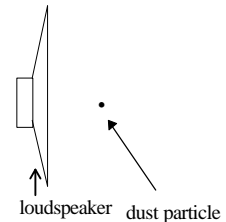


How, if at all, can the demonstrator repeat the original experiment to produce a pulse that takes a longer time to reach the wall. More than one answer may be correct. If so, **give them all**. **Circle the correct letter or letters.** Explain.

Possible responses for question 1:

- Move her hand more quickly (but still only up and down once and still by the same amount).
- Move her hand more slowly (but still only up and down once and still by the same amount).
- Move her hand a larger distance but up and down in the same amount of time.
- Move her hand a smaller distance but up and down in the same amount of time.
- Use a heavier string of the same length, under the same tension
- Use a lighter string of the same length, under the same tension
- Use a string of the same density, but decrease the tension.
- Use a string of the same density, but increase the tension.
- Put more force into the wave.
- Put less force into the wave.
- none of the above.

4. A dust particle is located in front of a silent loudspeaker (see figure). The loudspeaker is turned on and plays a note at a constant (low) pitch. **Which choice or combination of the choices $a-f$** (listed below) can describe the motion of the dust particle after the loudspeaker is turned on? **Circle the correct letter or letters.** Explain.



Possible responses for question 2:

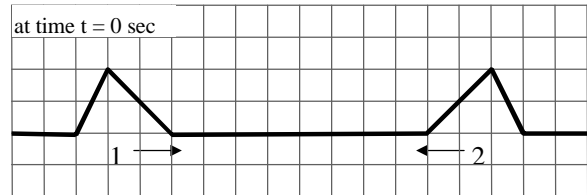
- The dust particle will move up and down.
- The dust particle will be pushed away from the speaker.
- The dust particle will move side to side.
- The dust particle will not move at all.
- The dust particle will move in a circular path.
- None of these answers is correct.

UMD Wave Diagnostic Test

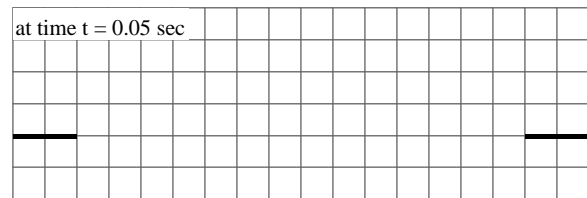
5. Michael and Laura are standing 100 m apart and yell “Yo!” at each other at exactly the same instant. Michael yells louder than Laura, and the pitch (frequency) of his voice is lower. No wind is blowing.

Will Laura hear Michael first, Michael hear Laura first, or will they hear each other at the same time? Explain how you arrived at your answer.

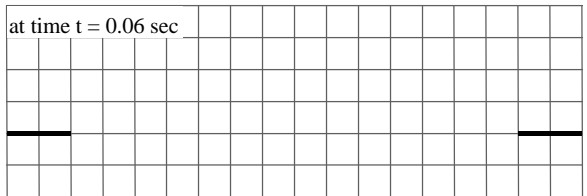
6. Consider two pulses on a spring, as shown in the figure to the right. They are moving toward each other at 100 cm/sec. Each block in the picture represents 1 cm.



In the figure to the right, sketch the shape of the spring after 0.05 sec have elapsed. Explain how you arrived at your answer.



In the figure to the right, sketch the shape of the spring after 0.06 sec have elapsed. Explain how you arrived at your answer.



7. Margaret stands 30 m from a large wall and claps her hands together once. A short moment later, she hears an echo.

How, if at all, would the time it takes for her to hear the echo change if she clapped her hands harder? Explain.

Consider a dust particle floating in the air very close to the wall (within 0.1 mm). Describe the motion, if any, of this dust particle between the moment that Margaret claps and the moment she hears the echo. Explain how you arrived at your answer.