AP® PHYSICS
2012 SCORING GUIDELINES

General Notes About 2012 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded in part (b). One exception to this practice may occur in cases where the numerical answer to a later part should easily be recognized as wrong, for example, a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if the use of an equation expressing a particular concept is worth 1 point, and a student’s solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression, it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics Exam equation sheets. For a description of the use of such terms as “derive” and “calculate” on the exams, and what is expected for each, see “The Free-Response Sections — Student Presentation” in the *AP Physics Course Description*.

4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$, but use of 10 m/s^2 is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer owing to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will eliminate the level of accuracy required to determine the difference in the numbers, and some credit may be lost.

Question 6

10 points total	**Distribution of points**
(a) and (b) 6 points — These two parts are closely linked; therefore they are scored as a unit.	
For indicating the use of the sine-wave generator to send a sound wave of a given frequency into the glass tube	1 point
For indicating adjustment of the movable piston until the sound picked up by the microphone and shown on the waveform display indicates that resonance occurs (maximum amplitude of standing wave) or until resonance is heard by ear	1 point
For indicating the use of the meterstick to measure the distance L from the piston to the left-hand end of the tube at resonance	1 point
For a statement indicating that L is proportional, but not equal, to the wavelength	1 point
For defining variables for frequency and wavelength	1 point
For indicating that $v = \lambda f$ should be used with the measurements to determine an experimental value of the speed of sound	1 point

<u>Example</u>

Send a sound wave of frequency f into the glass tube using the sine-wave generator and speaker. Move the piston all the way to the left end of the tube. Pull the piston to the right until the sound picked up by the microphone and shown on the waveform display indicates that resonance occurs. Use the meterstick to measure the distance L between the piston and the left-hand end of the tube. For a tube closed at one end, the wavelength λ is equal to $4L/n$, with the first resonance at $n = 1$. Using the above measurements, an experimental value of the speed of sound can be determined using the equation $v = \lambda f$.

Question 6 (continued)

	Distribution of points
(c) 4 points	
For indicating an appropriate variable that can be varied to obtain multiple sets of data	1 point
For correctly identifying appropriate independent and dependent variables to be graphed	1 point
For indicating an appropriate plot that will produce a linear graph	1 point
For stating how the slope of this graph can be used to determine the speed of sound υ	1 point

Examples

One of the measured variables that could be varied in order to obtain multiple sets of data is the frequency f. If f is varied, this means it is the independent variable, and the dependent variable is the wavelength λ. A plot of λ versus $1/f$ will produce a linear graph, the slope of which is the speed of sound.

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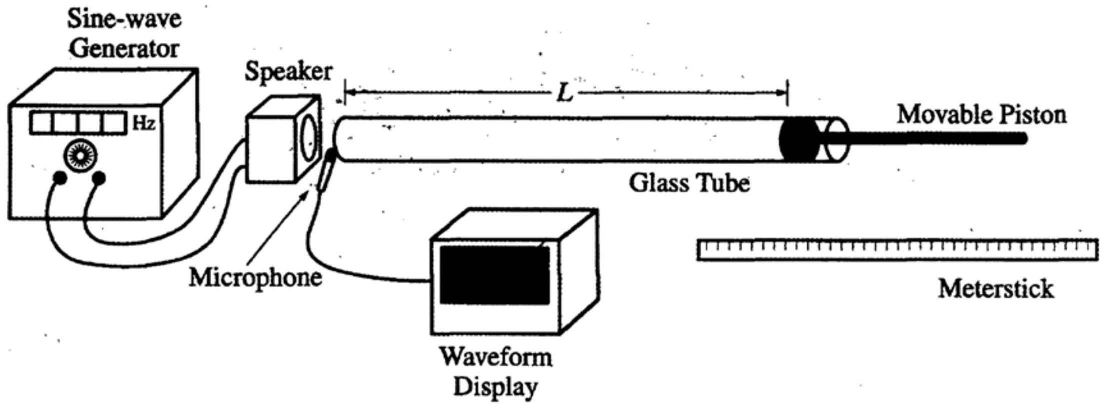

B6-A

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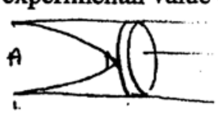
6. (10 points)

You are given the apparatus represented in the figure above. A glass tube is fitted with a movable piston that allows the indicated length L to be adjusted. A sine-wave generator with an adjustable frequency is connected to a speaker near the open end of the tube. The output of a microphone at the open end is connected to a waveform display. You are to use this apparatus to measure the speed of sound in air.

(a) Describe a procedure using the apparatus that would allow you to determine the speed of sound in air. Clearly indicate what quantities you would measure and with what instrument each measurement would be made. Represent each measured quantity with a different symbol.

- Set the sine-wave generator to a specific frequency (f)
- Move the piston all the way to the open end of the tube
- Slowly pull the piston out until a standing wave pattern appears on the waveform display
- Measure the length of the tube (L)

(b) Using the symbols defined in part (a), indicate how your measurements can be used to determine an experimental value of the speed of sound.



$v = \lambda f$ $\quad \frac{1}{4}\lambda = L$

$\lambda = 4L$

$\therefore v = 4Lf$

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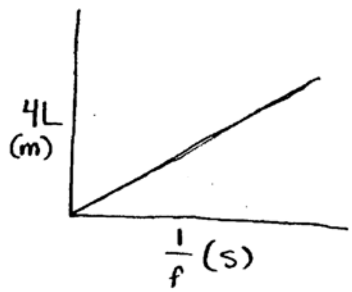
(c) A more accurate experimental value can be obtained by varying one of the measured quantities to obtain multiple sets of data. Indicate one quantity that can be varied, and describe how a graph of the resulting data could be used to determine the speed of sound. Clearly identify independent and dependent variables, and indicate how the slope of the graph relates to the speed of sound.

One quantity that can be varied is the frequency of the sine-wave generator.

The independent variable is the frequency, and the dependent variable is the length of the tube required to produce a standing wave pattern



Since $v = 4Lf$, a graph of $(\frac{1}{f})$ vs. 4L would produce a slope of the speed of sound in air.

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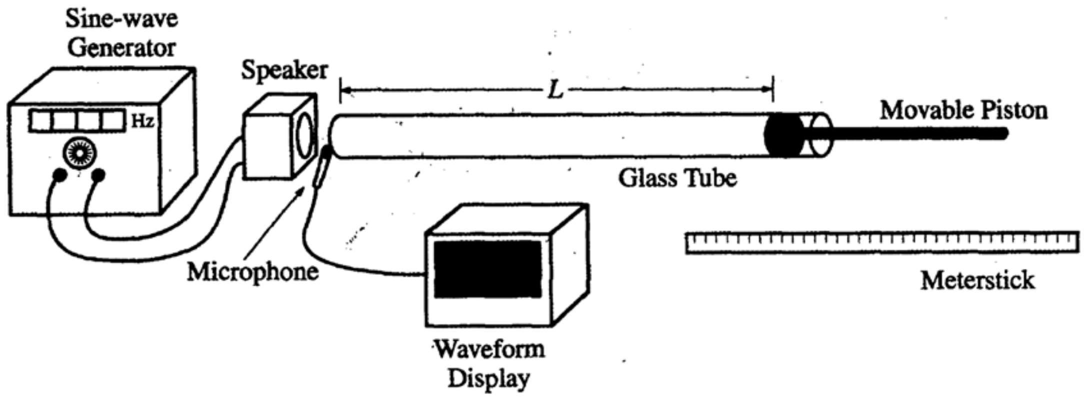

B6-B
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6. (10 points)

You are given the apparatus represented in the figure above. A glass tube is fitted with a movable piston that allows the indicated length L to be adjusted. A sine-wave generator with an adjustable frequency is connected to a speaker near the open end of the tube. The output of a microphone at the open end is connected to a waveform display. You are to use this apparatus to measure the speed of sound in air.

(a) Describe a procedure using the apparatus that would allow you to determine the speed of sound in air. Clearly indicate what quantities you would measure and with what instrument each measurement would be made. Represent each measured quantity with a different symbol.

The wave generator will be turned on, which will produce a frequency f and will pass through the speaker. As it does it will then go into the glass tube that will have a diff wavelength λ. The value of λ can be adjusted with the piston and measured with the meterstick. Various relations can be tried to establish diff relationships between λ & f to come up with $c = f\lambda$.

(b) Using the symbols defined in part (a), indicate how your measurements can be used to determine an experimental value of the speed of sound.

f → frequency

λ → wavelength

$c = f\lambda$

Diff procedures can be used to determine the relationship between f & λ and hence speed of sound c can be calculat.

(c) A more accurate experimental value can be obtained by varying one of the measured quantities to obtain multiple sets of data. Indicate one quantity that can be varied, and describe how a graph of the resulting data could be used to determine the speed of sound. Clearly identify independent and dependent variables, and indicate how the slope of the graph relates to the speed of sound.

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The value of λ(wavelength can differ). By adjusting diff frequencies we can get diff λ.

In this cas f is the independent variable & λ is variable.

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B6-C

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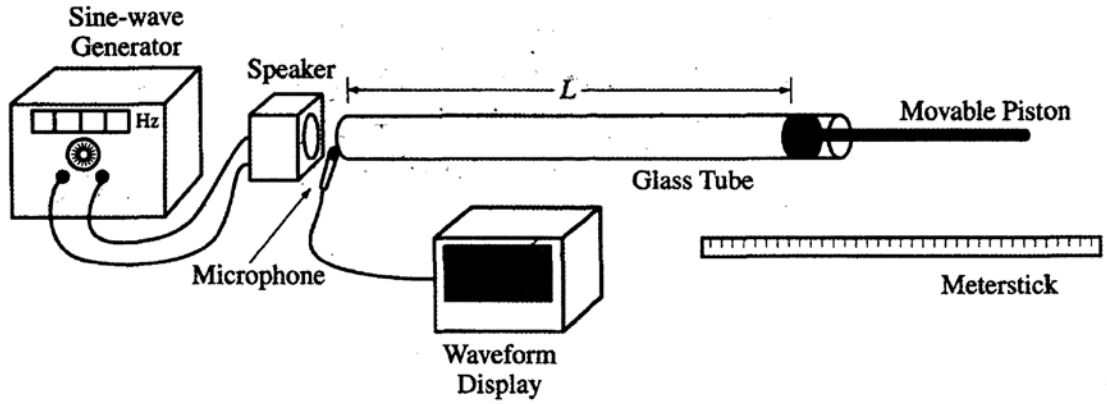


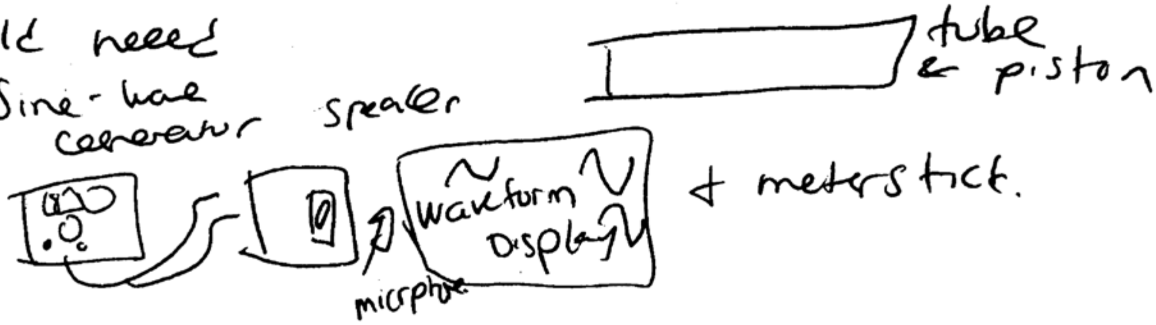
6. (10 points)

You are given the apparatus represented in the figure above. A glass tube is fitted with a movable piston that allows the indicated length L to be adjusted. A sine-wave generator with an adjustable frequency is connected to a speaker near the open end of the tube. The output of a microphone at the open end is connected to a waveform display. You are to use this apparatus to measure the speed of sound in air.

(a) Describe a procedure using the apparatus that would allow you to determine the speed of sound in air. Clearly indicate what quantities you would measure and with what instrument each measurement would be made. Represent each measured quantity with a different symbol.

I would measure freqency + λ.

I would need



(b) Using the symbols defined in part (a), indicate how your measurements can be used to determine an experimental value of the speed of sound.

My measurements can be used to determine the experimental value of speed of sourch because the apperatus would measure freqency + also λ. This would determine ~~sound~~.

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(c) A more accurate experimental value can be obtained by varying one of the measured quantities to obtain multiple sets of data. Indicate one quantity that can be varied, and describe how a graph of the resulting data could be used to determine the speed of sound. Clearly identify independent and dependent variables, and indicate how the slope of the graph relates to the speed of sound.

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B6-C

→ The slope increases when speed of sound increases.

→ length of tube could be varied

Independent	Dependent
length changes	wave generator stays same.

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AP® PHYSICS B
2012 SCORING COMMENTARY

Question 6

Overview

This question assessed students' understanding of lab measurements and procedures by asking them to experimentally determine the speed of sound in air with a given set of tools. It assessed their knowledge of standing waves, and particularly sound wave resonance, in a tube closed at one end and open at the other.

Sample: B6-A
Score: 9

Parts (a) and (b) are well organized, with an indication of the use of the sine-wave generator to create a sound wave with a specific frequency, the use of the waveform display to determine a standing wave, the use of the meterstick to measure the length of the tube, a statement that relates the length of the tube to the wavelength, and a statement indicating that $v = \lambda f$ is to be used to determine the speed of sound in air. Only 1 point was lost, because the variable for wavelength is not defined (both frequency and wavelength must be defined to earn this point). Full credit was earned in part (c), because the student indicates that frequency varies and is therefore the independent variable, whereas length is the dependent variable. A sketch of a plot of four times length versus the inverse of frequency is provided, and it is clear that the slope of this graph is the speed of sound in air.

Sample: B6-B
Score: 5

In parts (a) and (b) 3 points were awarded for the description of the experimental procedure, which indicates the use of the sine-wave generator to create a sound wave with a specific frequency; a clear definition of both frequency and wavelength; and a statement indicating that $v = \lambda f$ is to be used to determine the speed of sound in air. The student does not indicate that the waveform display should be used to determine resonance, that the meterstick should be employed to measure the length of the tube, or provide a statement concerning the proportionality of the length of the tube to the wavelength. Two points were earned in part (c) for an indication that frequency can be adjusted and is therefore the independent variable and that length is the dependent variable. However, the student makes no reference to what variables should be plotted to make a graph, nor is the slope of any graph mentioned in determining the speed of sound in air.

Sample: B6-C
Score: 1

No credit was awarded in parts (a) and (b) because no description of an experimental procedure is included, nor is there any indication about how measurements could be used to determine the speed of sound in air. The variables are also not defined. One point was earned in part (c) for the indication that the length can be varied. No points were awarded for indicating the independent and dependent variables, because the wave generator is named as the dependent variable. There is no mention in part (c) of a plot of data; therefore, the mention of the slope of a graph is insufficient.