AP® PHYSICS
2011 SCORING GUIDELINES

General Notes About 2011 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 earned. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally earn credit. For example, if use of the equation expressing a particular concept is worth one 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 earned. 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 sheet. 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 $g = 9.8\ \mathrm{m/s^2}$, but use of $10\ \mathrm{m/s^2}$ is 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 due to differences in rounding throughout the question typically earn 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 lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

AP® PHYSICS B
2011 SCORING GUIDELINES

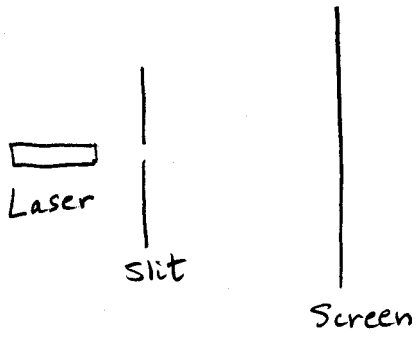
Question 3

15 points total | **Distribution of points**

(a) 2 points

For selection of a length-measuring device (meter stick or metric ruler) — 1 point
For selection of a light source (laser pointer or filament lamp AND prism) — 1 point

(b) 2 points



For a sketch of the equipment selected in part (a), including slit (meter stick or ruler not required) — 1 point
For labeling all the selected equipment, including the slit — 1 point

(c) 4 points

In the scoring of this part, the following aspects of the response earn points:
For shining the laser light through the slit — 1 point
For using the meter stick or ruler to measure at least one distance to be used in the calculation — 1 point
For measuring the distance from the slit to the screen or wall — 1 point
For making reference to some interference pattern formed on the screen or wall — 1 point
Example:

Set up the equipment as shown in the diagram. Shine the laser light through the slit to form a diffraction pattern on the screen. Using the meter stick, measure the distance L between the slit and the screen. Using the metric ruler, measure the width Δx of the central bright maximum on the screen.

Question 3 (continued)

Distribution of points

(d) 5 points

In the scoring for this part, the following aspects of the explanation earn points:

For including correct expressions for single-slit diffraction, such as the following: 1 point

$x_m = \frac{m\lambda L}{d}$ AND some indication that this is valid only for the small angle approximation, such as saying that $L >> x_m$

OR

$m\lambda = d\sin\theta$ AND $\tan\theta = x_m/L$

For solving for a correct expression for d 1 point

For using the measurements described in part (c) 1 point

For correctly identifying m, consistent with a single-slit diffraction pattern 2 points

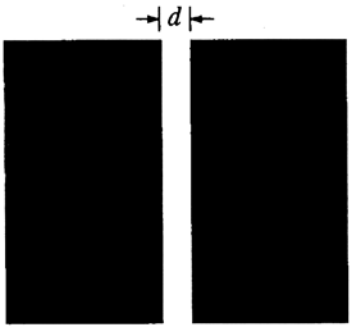
Example:

Because $L >> x_m$, the relationship that applies is $x_m = \frac{m\lambda L}{d}$, where x_1 is the distance from the center of the diffraction pattern to the first minimum. This is half the width Δx measured in part (c). L is the distance between the slit and the screen. The final expression for d is $d = \frac{2\lambda L}{\Delta x}$.

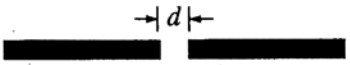
(e) 2 points

For indicating that the central bright maximum gets narrower or that the fringes get closer together 1 point

For indicating in the explanation that since x is proportional to $1/d$, if d increases, then x decreases 1 point



Front View



Top View

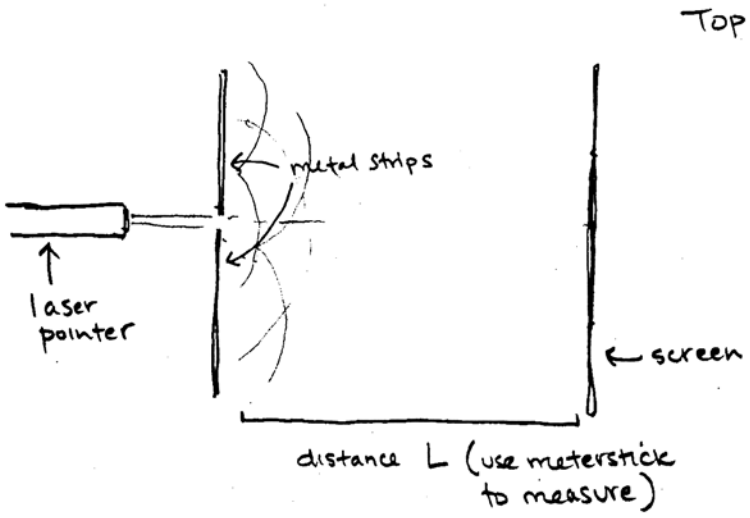
3. (15 points)

Two metal strips are brought together until their edges are separated by a small distance d, forming a narrow slit, as represented above. You are to design a laboratory experiment to determine the width of the slit.

(a) From the following list of available equipment, check those additional items you would use for the purpose of determining the slit width d.

✓ Laser pointer (λ = 635 nm)	✓ Meterstick
____ Mirror	____ Metric ruler
✓ Screen	____ Prism
____ Filament lamp	____ Stopwatch

(b) Sketch a diagram of your experimental setup and label the pieces of equipment that would be used.



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(c) Outline the experimental procedure you would use, including a list of quantities you would measure. For each quantity, identify the equipment you would use to make the measurement.

1. measure length L between screen and metal strips with meterstick
2. project laser toward the screen and through the gap, producing an interference pattern.
3. measure the distance x from the line parallel to L and directly ahead of the laser to the first dark spot. with meterstick.

(d) Explain how you would calculate the slit width d by using the measured quantities identified in (c).

$d \sin\theta = m\lambda$ $\qquad d\frac{x}{L} = m\lambda$

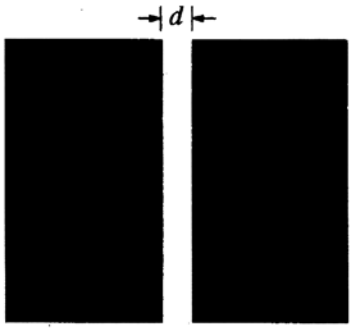
small $\angle = \frac{x}{L}$

because we know λ (635nm) and have measured the distance (x) to the first order ($m = 1$) dark slit projected on a screen a distance L from the slit, we can calculate d.

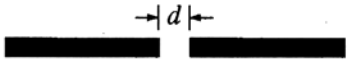
(e) Suppose the separation d between the strips was increased, but everything else was kept the same. What changes would you expect to observe? Explain your reasoning.

$\uparrow d \frac{\downarrow x}{L} = m\lambda$

The distance between successive dark strips would decrease; the bright central maximum would be smaller.



Front View



Top View

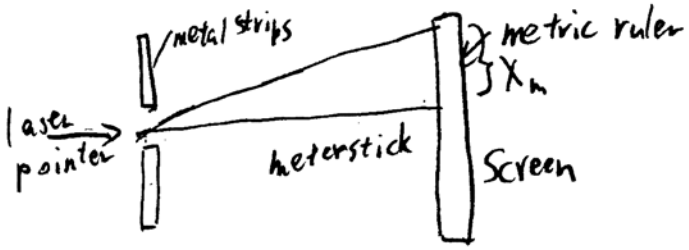
3. (15 points)

Two metal strips are brought together until their edges are separated by a small distance d, forming a narrow slit, as represented above. You are to design a laboratory experiment to determine the width of the slit.

(a) From the following list of available equipment, check those additional items you would use for the purpose of determining the slit width d.

X Laser pointer (λ = 635 nm)	X Meterstick
____ Mirror	X Metric ruler
X Screen	____ Prism
____ Filament lamp	____ Stopwatch

(b) Sketch a diagram of your experimental setup and label the pieces of equipment that would be used.



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(c) Outline the experimental procedure you would use, including a list of quantities you would measure. For each quantity, identify the equipment you would use to make the measurement.

step up screen L (meters) from the slit, measuring using meter stick
shine laser pointer ($\lambda = 635$ nm) (given) through slit, measuring x_m using metric ruler

(d) Explain how you would calculate the slit width d by using the measured quantities identified in (c).

$x_m = \frac{\lambda L}{d}$

$d = \frac{\lambda L}{x_m}$

∵ λ is given, and L and x_m are measured.
we can calculate d

(e) Suppose the separation d between the strips was increased, but everything else was kept the same. What changes would you expect to observe? Explain your reasoning.

I would observe x_m (see diagram left) to decrease.
∵ x_m is inversely proportional to d, when d increases, x_m decreases.

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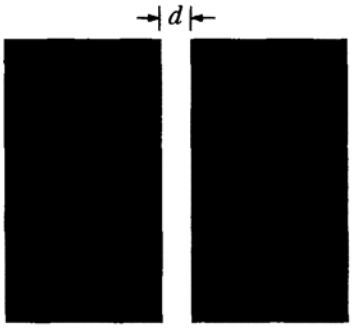
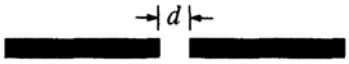


Front View



Top View

3. (15 points)

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(a) From the following list of available equipment, check those additional items you would use for the purpose of determining the slit width d.

✓ Laser pointer (λ = 635 nm)	✓ Meterstick
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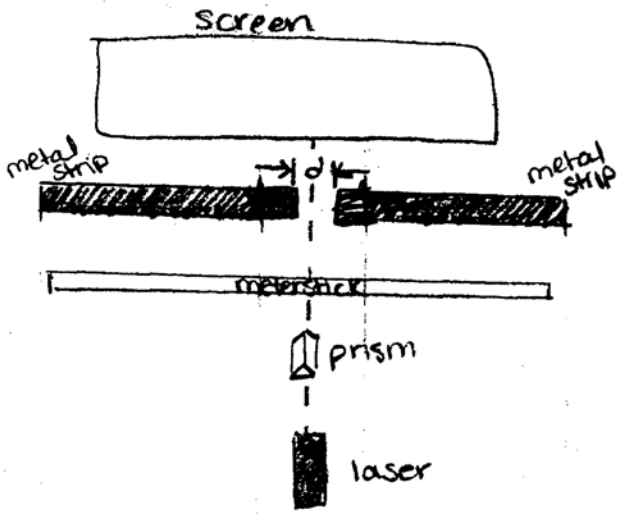
(b) Sketch a diagram of your experimental setup and label the pieces of equipment that would be used.



(c) Outline the experimental procedure you would use, including a list of quantities you would measure. For each quantity, identify the equipment you would use to make the measurement.

1) aline the laser and prism to aline the difraction segments caused from the prism to the slit
2) once alined measure the slit distance from the difraction segments made from the prism & laser on the screen to find the distance of the slit.
3) move the distance of the prism and repeat steps 1 + 2

(d) Explain how you would calculate the slit width d by using the measured quantities identified in (c).

The segments made from the prism + laser could be used to measure the distance between the two metal strips.

(e) Suppose the separation d between the strips was increased, but everything else was kept the same. What changes would you expect to observe? Explain your reasoning.

The prism would have to be moved closer to the metal strips so the difraction segments would be larger, that way the distance can be measured.

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AP® PHYSICS B
2011 SCORING COMMENTARY

Question 3

Overview

This lab question required the design of a single-slit experiment using light. It assessed students' knowledge of the interference of light and methods of performing measurements involving the interference pattern.

Sample: B3A
Score: 15

This response includes all the required components and demonstrates a strong understanding of single-slit diffraction.

Sample: B3B
Score: 10

Parts (a) and (b) earned full credit. Part (c) did not earn 1 point because the student never defines what x_m means. Merely mentioning x_m does not indicate understanding of the formation of an interference pattern. Part (d) earned 2 points: 1 for using measured values from part (c) and 1 for solving for *d*. Part (e) earned 1 point for an explanation using the mathematical relationship. The second point was not earned because there is no reference to fringes or any interference pattern to demonstrate an understanding of what x_m means.

Sample: B3C
Score: 6

Parts (a) and (b) earned all points. Points were not deducted for selecting the prism, and all the chosen equipment was included in the diagram. Labeling the metal strips indicates the presence of the slit, as does labeling the separation as *d*. Part (c) earned 2 points: 1 for indicating a distance measurement and 1 for referencing a diffraction pattern on the screen. Parts (d) and (e) earned no credit.