# AP® PHYSICS B (Form B)
# 2007 SCORING GUIDELINES

## General Notes About 2007 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. 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 receive 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 awarded. However, when students are asked to derive and 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 $g = 9.8 \text{ m/s}^2$ , but use of $10 \text{ m/s}^2$ is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

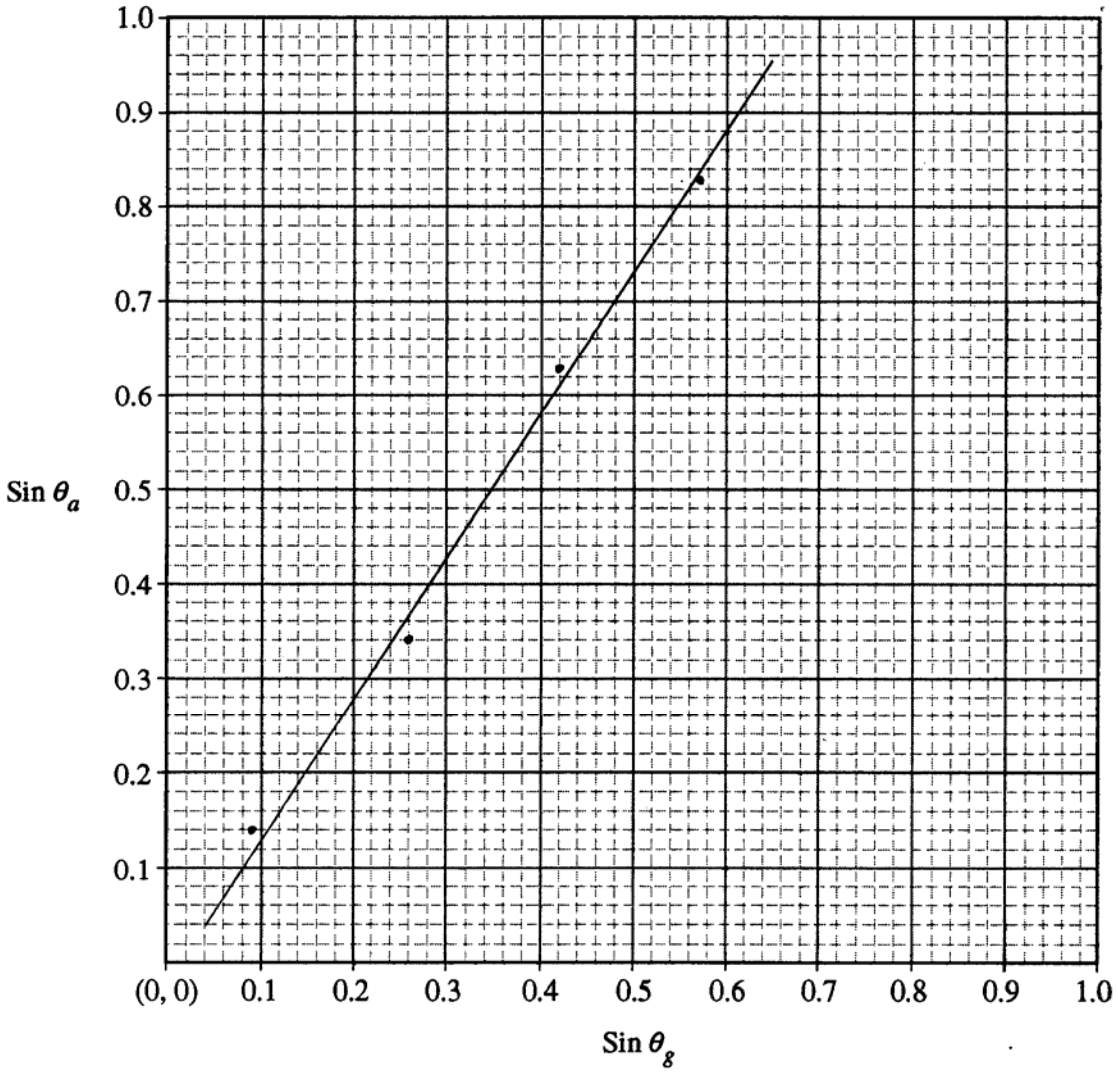
5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences 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 lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

# AP® PHYSICS B
# 2007 SCORING GUIDELINES (Form B)

## Question 6

**10 points total** **Distribution of points**

(a) 3 points




| | |
|---|---|
| For at least three data points plotted correctly | 1 point |
| For a straight line drawn | 1 point |
| For the line being a "best fit" to the data points (with equal number of points above and below the line) | 1 point |

**Question 6 (continued)**

**Distribution of points**

(b) 3 points

$n_a \sin\theta_a = n_g \sin\theta_g$

$n_a = 1$

For recognizing that $n_g$ is the slope of the graph of $\sin\theta_a$ versus $\sin\theta_g$. 1 point

$\sin\theta_a = n_g \sin\theta_g$

For using at least two widely separated points on the best-fit line (not two data points) 1 point
For example, selecting two points on the line in the graph above, such as (0.08,0.10) and (0.60,0.88)

Slope = $\frac{\Delta y}{\Delta x} = \frac{0.88 - 0.10}{0.60 - 0.08} = 1.5$

For the correct slope value, hence the value for $n_g$ 1 point

$n_g = 1.5$

(c) 2 points

The critical angle $\theta_c$ is equal to $\theta_g$ when $\sin\theta_a = 1$

For extending the best-fit line to the point at the top of the graph where $\sin\theta_a = 1$ 1 point

For indicating that $\theta_c = \sin^{-1}(\sin\theta_g)$ at this point. (*Note: To earn this point it was not required to calculate the actual value for $\theta_c$.*) 1 point

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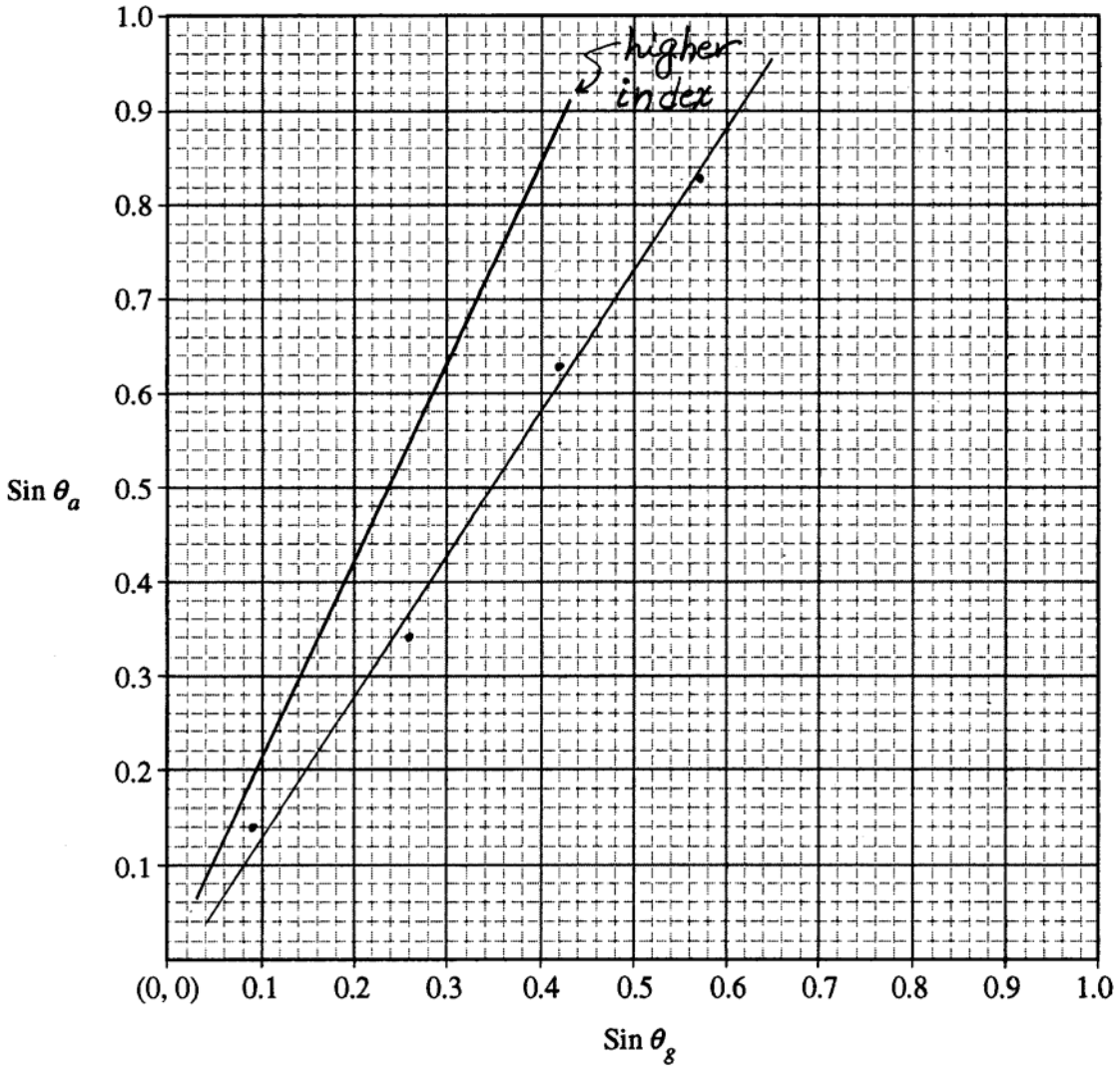
## Question 6 (continued)

**Distribution of points**

(d) 2 points



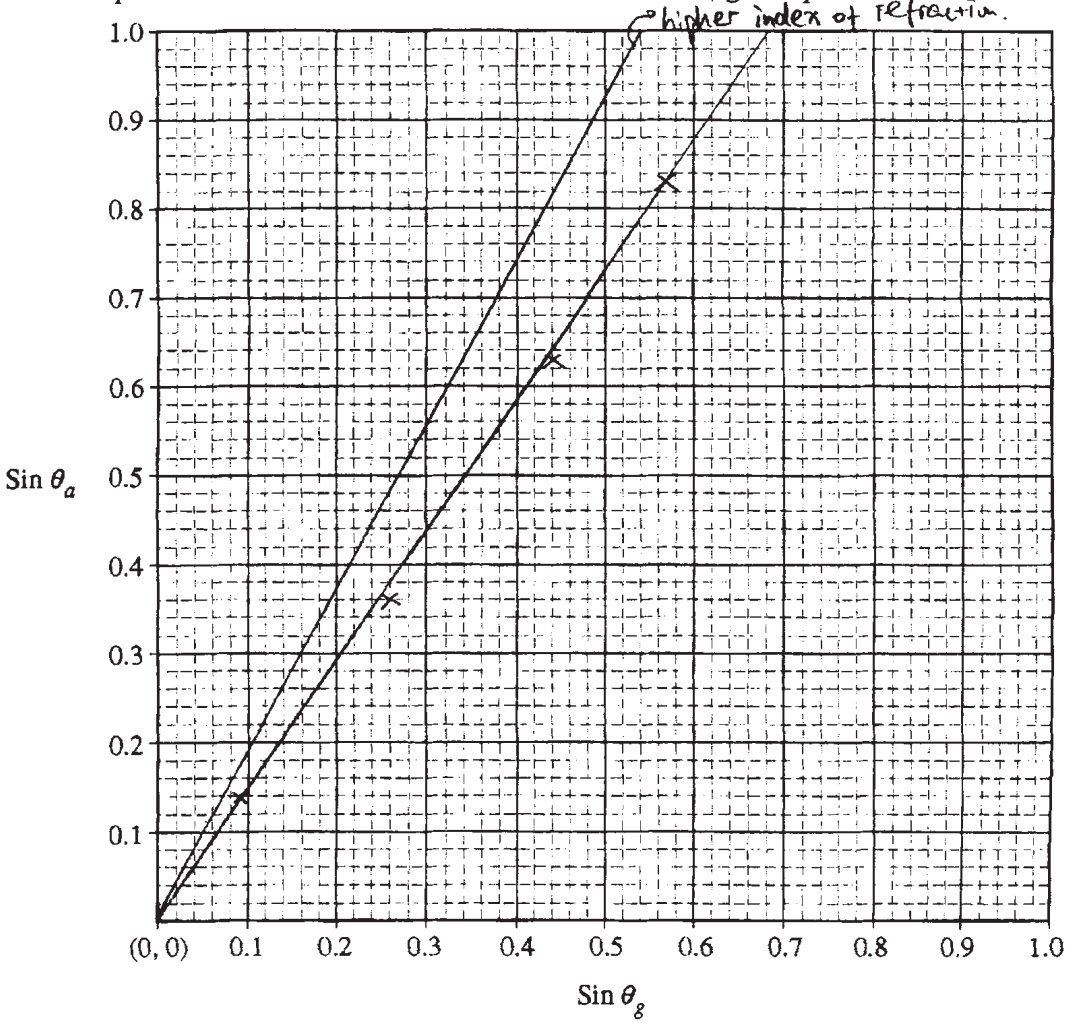

For a line with a slope greater than the best-fit line of part (a) 1 point
For the line intercepting the origin (0,0) 1 point

6. (10 points)

A student is asked to determine the index of refraction of a glass slab. She conducts several trials for measurement of angle of incidence $\theta_a$ in the air versus angle of refraction $\theta_g$ in the glass at the surface of the slab. She records her data in the following table. The index of refraction in air is 1.0.

| Trial # | $\theta_g$ (degrees) | $\theta_a$ (degrees) | Sin $\theta_g$ | Sin $\theta_a$ |
|---|---|---|---|---|
| 1 | 5.0 | 8.0 | 0.09 | 0.14 |
| 2 | 15 | 21 | 0.26 | 0.36 |
| 3 | 25 | 39 | 0.42 | 0.63 |
| 4 | 35 | 56 | 0.57 | 0.83 |

(a) Plot the data points on the axes below and draw a best-fit line through the points.




GO ON TO THE NEXT PAGE.

(b) Calculate the index of refraction of the glass slab from your best-fit line.

By Snell's Law

$n_{air} \sin\theta_a = n_g \sin\theta_g$

$\frac{\sin\theta_a}{\sin\theta_g} = n_g$

gradient of the graph $= \frac{0.83 - 0.14}{0.57 - 0.05}$

$\approx 1.4$

$\therefore n_g = 1.4.$

(c) Describe how you could use the graph to determine the critical angle for the glass-air interface. Do not use the answer to the part (b) for this purpose.

Extend the best fit line until it reaches the value $\sin\theta_a = 1$, and find the $x$ coordinate. Critical angle $= \sin^{-1}(x \text{ coordinate})$ $\theta_a = 90°$

Since at critical angle $\sin\theta_a = \sin 90° = 1$

$n_g \sin\theta_g = n_a \sin\theta_a = 1$

on the graph, the $x$ coordinate of the point with $\sin\theta_a = 1$ is equal to the sin value of the critical angle, which is 0.68 in the graph.

$\therefore$ Critical angle $= \sin^{-1}(0.68)$

(d) On the graph in (a), sketch and label a line for a material of higher index of refraction.

6. (10 points)

A student is asked to determine the index of refraction of a glass slab. She conducts several trials for measurement of angle of incidence $\theta_a$ in the air versus angle of refraction $\theta_g$ in the glass at the surface of the slab. She records her data in the following table. The index of refraction in air is 1.0.

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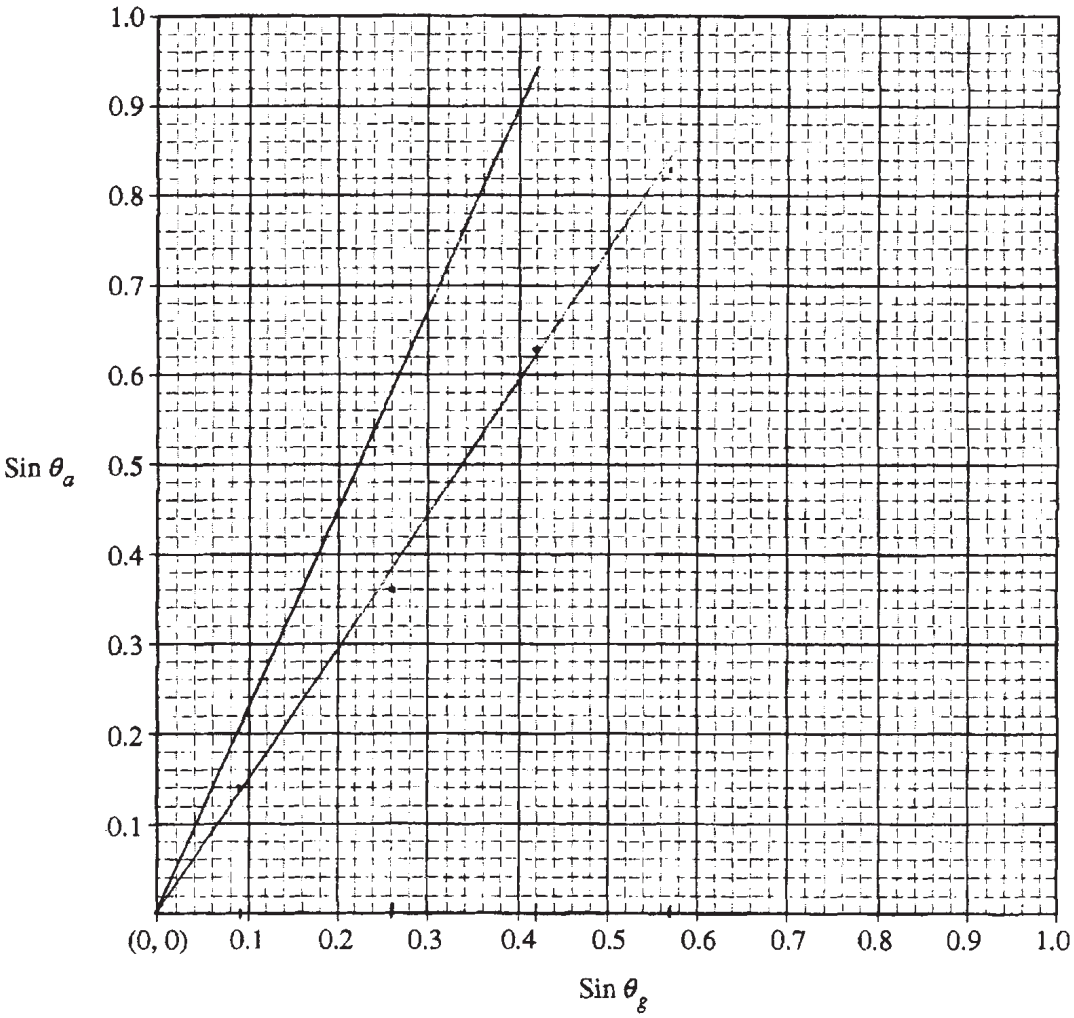


**GO ON TO THE NEXT PAGE.**

(b) Calculate the index of refraction of the glass slab from your best-fit line.

$$\frac{\sin\theta_a}{\sin\theta_g} = \frac{n}{1} = n$$

$n_1 = 1.56$
$n_2 = 1.38$
$n_3 = 1.5$
$n_4 = 1.45$

$n_{avg} = 1.47$

(c) Describe how you could use the graph to determine the critical angle for the glass-air interface. Do not use the answer to the part (b) for this purpose.

when $\sin\theta_a = 1$.

$$\frac{1}{\sin\theta_g} = n$$

$$\sin\theta_g = \frac{1}{n} = 0.68$$

$\sin^{-1}(0.68) = 42.84°$

critical angle is 42.84°

(d) On the graph in (a), sketch and label a line for a material of higher index of refraction.

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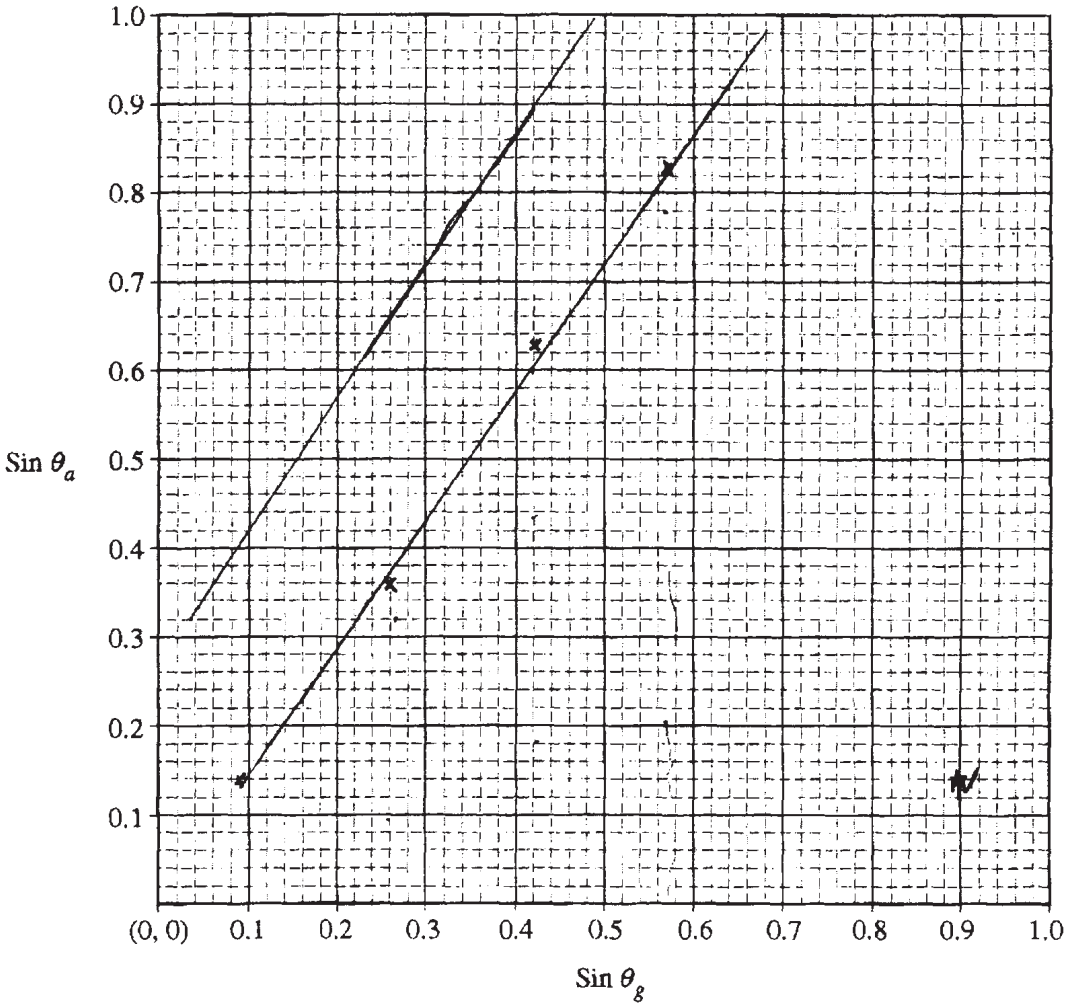


GO ON TO THE NEXT PAGE.

(b) Calculate the index of refraction of the glass slab from your best-fit line.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n = \frac{c}{v}$

(c) Describe how you could use the graph to determine the critical angle for the glass-air interface. Do not use the answer to the part (b) for this purpose.

Simply looking at the graph, and the table, the values tell us what has to be used to find the critical angle.

(d) On the graph in (a), sketch and label a line for a material of higher index of refraction.

# AP® PHYSICS B
# 2007 SCORING COMMENTARY (Form B)

## Question 6

**Sample: B6A**
**Score: 9**

The only point lost in the response was for the best-fit line in part (a), where two of the points are below the line and none above it. Although the point for trial 3 is off, the other three points are plotted correctly. The calculation in part (b) uses two data points, but these points are also on the line, so there was no deduction there. The description in part (c) is very well written.

**Sample: B6B**
**Score: 7**

This response earned full credit for parts (a), (c), and (d) but no credit for part (b) because there is no attempt to use the best-fit line, as required. Instead, the student calculates the index of refraction from Snell's law for each of the data points and then takes the average. While this is a reasonable procedure, the question specifically states that the best-fit line is to be used.

**Sample: B6C**
**Score: 3**

The only points given for this response were the 3 points in part (a) for correctly plotting the data points and drawing a reasonable best-fit straight line.