AP® PHYSICS B
2010 SCORING GUIDELINES (Form B)

General Notes

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for the 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 — for example, 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 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 Exams 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*.

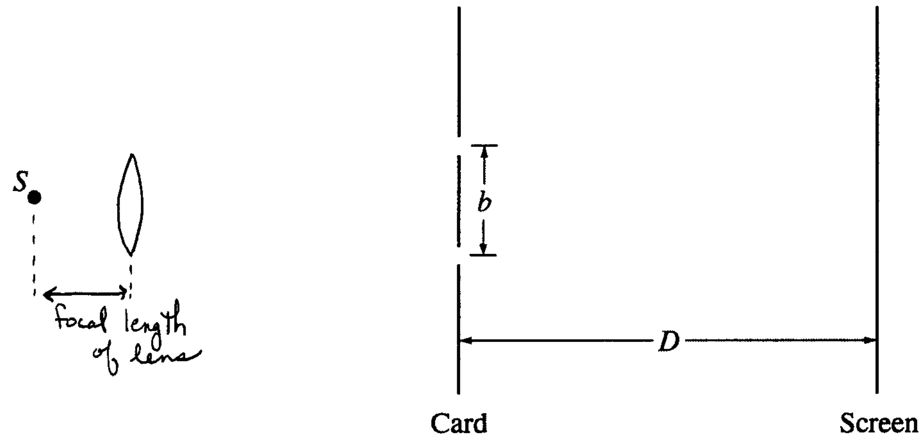
4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$, but use of 10 m/s^2 is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

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.

Question 5

10 points total **Distribution of points**

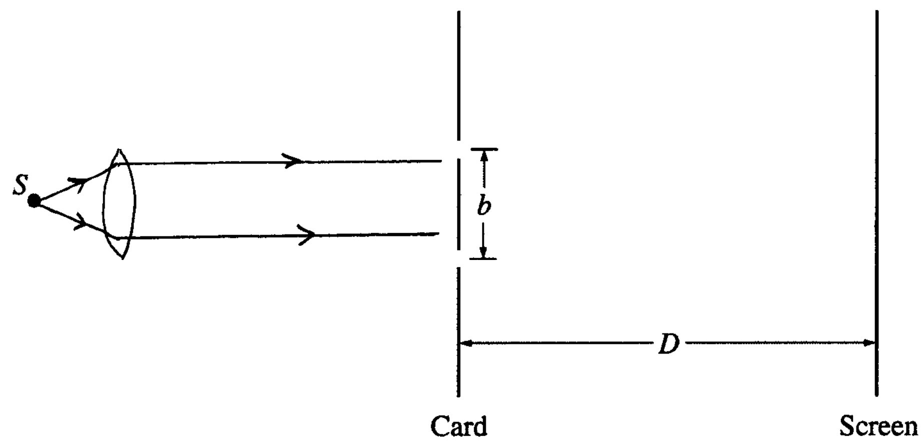
(a) 1 point



Note: Figure not drawn to scale.

For drawing the lens between the source and the card, and indicating that the lens is one focal length from the source — 1 point

(b) 2 points



Note: Figure not drawn to scale.

For drawing diverging rays from the source to the lens — 1 point
For drawing parallel rays from the lens to the card — 1 point
One earned point was deducted if a diverging lens was drawn, if it was obvious that a mirror was being used, or if the lens was set right next to the card.

Question 5 (continued)

Distribution of points

(c) 4 points

For using the correct equation $b\sin\theta = m\lambda$	1 point
For the correct approximation for $\sin\theta$ $\sin\theta \approx y_3/D$	1 point
For correctly substituting $m = 3$ $b(y_3/D) = 3\lambda$	1 point
For the correct answer $\lambda = by_3/3D$	1 point

Notes:

The first 2 points could also be earned by starting directly with the equation $x_m \approx \dfrac{m\lambda L}{d}$ from the equation table.

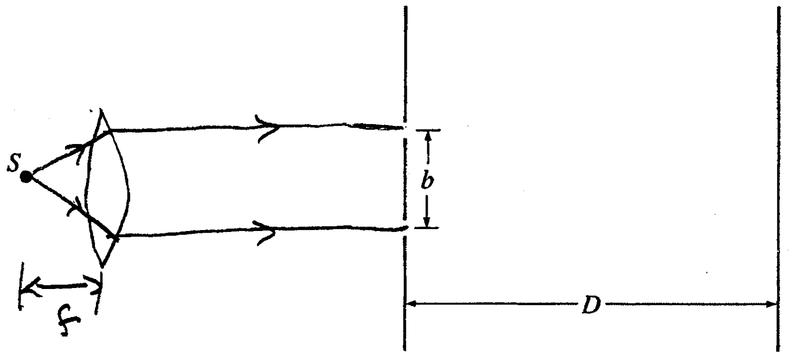
The second point was also earned for use of either of the exact relationships $\sin\theta = y_3\Big/\sqrt{y_3^2 + D^2}$ or $\theta = \tan^{-1}(y_3/D)$.

(d) 3 points

For indicating that the fringe spacing would decrease	1 point
For a clear, correct justification	2 points

For example: If the index of refraction increases, the wavelength in that region decreases. From the relationship in part (c), one can see that that means a decrease in fringe spacing.

No credit was awarded when multiple choices were marked unless they were affirmative and negative marks (e.g., a checkmark for the intended choice and an x for the others).



Note: Figure not drawn to scale.

5. (10 points)

In a double-slit interference experiment, a parallel beam of monochromatic light is needed to illuminate two narrow parallel slits of width w that are a distance b apart in an opaque card as shown in the figure above. A lens is inserted between the point light source S and the slits in order to produce the parallel beam of light. The interference pattern is formed on a screen a distance D from the slits, where $D >> b$.

(a) On the figure above, draw the lens at the appropriate place to produce the parallel beam of light, and label the location of the source relative to the lens with the appropriate optical parameter of the lens.

(b) Draw two light rays from the source to the slits to show the production of the parallel rays.

S is at the lens's focal point.

(c) In the interference pattern on the screen, the distance from the central bright fringe to the third bright fringe on one side is measured to be y_3. Derive an expression for the wavelength of the light in terms of the given quantities and fundamental constants.

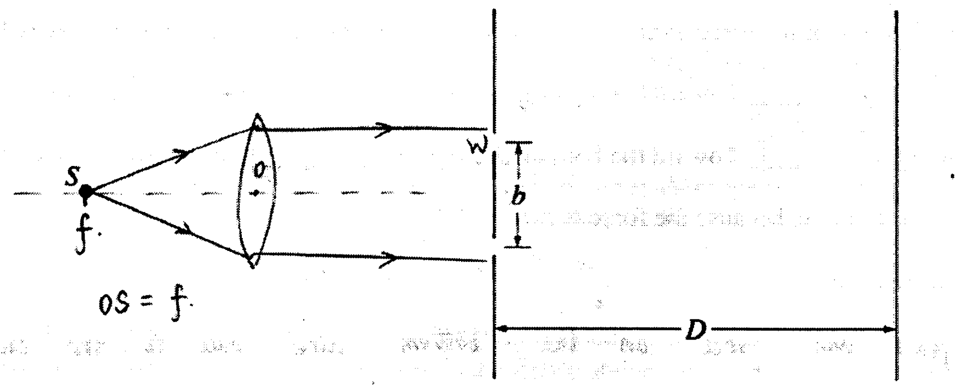
$$\lambda = b \sin\theta = \frac{b\left(y_3/3\right)}{D} = \frac{b y_3}{3D}$$

(d) If the space between the slits and the screen was filled with a material having an index of refraction $n > 1$, would the distance between the bright fringes increase, decrease, or remain the same?

___ Increase _✓_ Decrease ___ Remain the same

Explain your reasoning.

If the index of refraction goes up, the velocity and wavelength of the light both decrease. Since the distance between fringes is proportional to λ, that will decrease too.



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(a) On the figure above, draw the lens at the appropriate place to produce the parallel beam of light, and labe the location of the source relative to the lens with the appropriate optical parameter of the lens.

As shown above, OS = f (the focal length of the lens)

(b) Draw two light rays from the source to the slits to show the production of the parallel rays.

(c) In the interference pattern on the screen, the distance from the central bright fringe to the third bright fri on one side is measured to be y_3. Derive an expression for the wavelength of the light in terms of the gi quantities and fundamental constants.

$d\sin\theta = m\lambda$

$b\sin\theta = m\lambda$

$b\cdot\frac{y_3}{D} = 3\lambda$

$\lambda = \frac{y_3 b}{3D}$

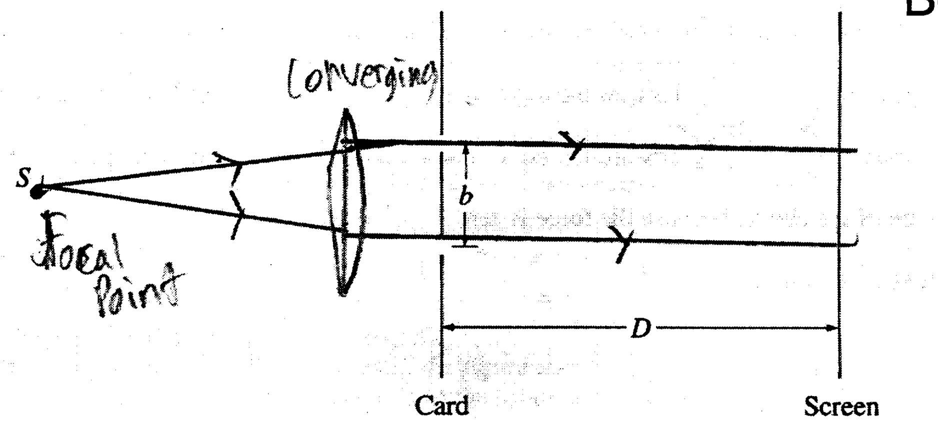
(d) If the space between the slits and the screen was filled with a material having an index of refraction $n > 1$, would the distance between the bright fringes increase, decrease, or remain the same?

_✓_ Increase ___ Decrease ___ Remain the same

Explain your reasoning.

As $n = \frac{c}{v} = \frac{\lambda_c f}{\lambda_m f} = \frac{\lambda_c}{\lambda_m} < 1$, $\lambda_m > \lambda_c$ and $d\sin\theta = m\lambda$, $\sin\theta$ would increases.

As $\sin\theta$ equals to the ratio of the distance between the bright fringes to the distance between card and screen which is a constant, the distance between the bright fringes would increase.



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(a) On the figure above, draw the lens at the appropriate place to produce the parallel beam of light, and label the location of the source relative to the lens with the appropriate optical parameter of the lens.

(b) Draw two light rays from the source to the slits to show the production of the parallel rays.

(c) In the interference pattern on the screen, the distance from the central bright fringe to the third bright fringe on one side is measured to be y_3. Derive an expression for the wavelength of the light in terms of the given quantities and fundamental constants.

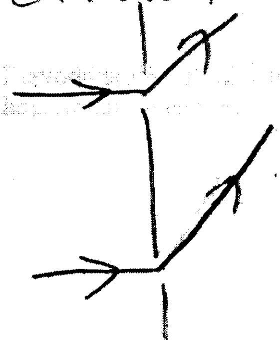
$$d = \frac{3\lambda}{\sin\theta}$$

(d) If the space between the slits and the screen was filled with a material having an index of refraction $n > 1$, would the distance between the bright fringes increase, decrease, or remain the same?

___ Increase   ___ Decrease   X Remain the same

Explain your reasoning.

The light from both slits will refract in the same direction



Question 5

Sample: B-5A
Score: 10

Correct work is shown for all parts, earning full credit. Note that the focal length is clearly indicated, both in the figure and verbally in part (b). In part (c), while it initially appears that the solution incorrectly uses $m = 1$, the corresponding fringe location is correctly expressed as $y_3/3$ so the solution is correct.

Sample: B-5B
Score: 7

Correct work is shown for parts (a), (b) and (c), earning full credit for those parts. Part (d) earned no credit because the wrong choice is selected as a result of using $n < 1$ instead of $n > 1$.

Sample: B-5C
Score: 4

Full credit was earned in parts (a) and (b); identification of the source location as the focal point is equivalent to labeling the focal length. One point was earned for writing the correct equation in part (c). Part (d) is completely incorrect, attributing a role to refraction that is inappropriate and very confused, and no credit was earned.