Physics II

Chapter 24 Practice

Spring 2018

IMPORTANT: Except for multiple-choice questions, you will receive no credit if you show only an answer, even if the answer is correct. Always show in the space on your answer sheet some sketches, words, or equations which clearly justify your answer. Show the equations you use and the values substituted into them whenever equations are necessary. If you go from a formula directly to an answer without showing the values used, you will lose points. Points will also be deducted for missing or erroneous units.

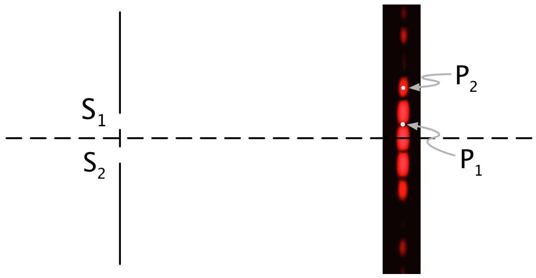
Each individual answer is weighted roughly evenly throughout the exam.

$$\frac{\text{path difference}}{d} = \sin\theta \qquad \frac{x}{L} = \tan\theta$$

Name ____

1. The particle model of light is attributed to

   (a) Albert Einstein.
   (b) Isaac Newton.
   (c) Christian Huygens.
   (d) Max Planck.



2. Consider point P_2, a point in the second bright fringe over from the center of the interference pattern shown above. The interference pattern is produced by red laser light of wavelength λ shining through two slits, S_1 and S_2. How much farther is point P_2 from S_2 than from S_1?

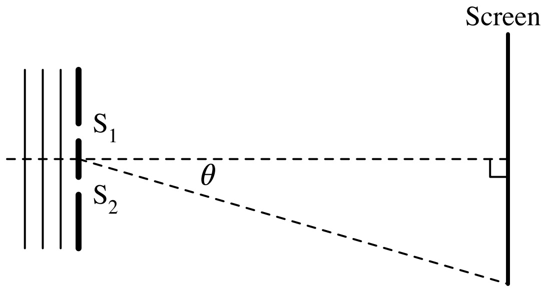
   (a) There is no difference in distance between P_2 and the two slits.
   (b) P_2 is half a wavelength farther from S_2 than from S_1.
   (c) P_2 is one wavelength farther from S_2 than from S_1.
   (d) P_2 is one and a half a wavelength farther from S_2 than from S_1.
   (e) P_2 is two wavelengths farther from S_2 than from S_1.

3. If the distance between the two slits in the diagram above is decreased, what will happen to the spacing between fringes compared to that shown above?

   (a) It will increase.
   (b) It will decrease.
   (c) The spacing will be the same as with the previous separation.

4. In a double-slit experiment, which of the following combinations of monochromatic light, slit-separation, and the slit-to-screen distance would produce the smallest, most compact interference pattern on the screen?

	Monochromatic light	Slit-separation	Slit-to-screen distance
(a)	red light	1 mm	1 m
(b)	red light	1 mm	2 m
(c)	red light	2 mm	1 m
(d)	green light	1 mm	2 m
(e)	green light	2 mm	1 m



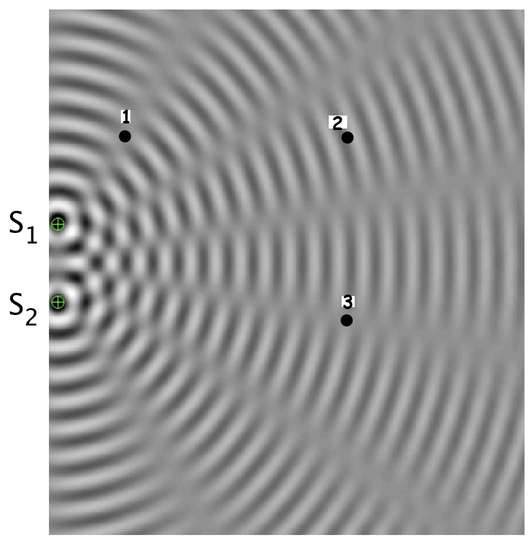
5. S_1 and S_2 shown above are narrow, parallel slits in an opaque plate. Light of wavelength λ is incident from the left moving in a direction perpendicular to the plate. On a screen far from the slits, there are maximums and minimums in intensity of the light at various angles measured from the center line. As the distance on the screen from the central antinode is increased from zero, the first minimum occurs at 1.3 cm. The next minimum will therefore occur at a position of

   (a) 2.6 cm.
   (b) 3.9 cm.
   (c) 5.2 cm.
   (d) 6.5 cm.
   (e) 7.8 cm.

6. What is the story behind Poisson's Spot? See the entry on the Physics II log on the web.

7. One of the patterns in the diagram above is produced by a laser shining through two slits. The other pattern arises from the same laser shining through a single slit. Identify which pattern is which.

   (a) The top pattern is a single slit diffraction pattern, and the bottom pattern is a double slit interference pattern.
   (b) The top pattern is a double slit interference pattern, and the bottom pattern is a single slit diffraction pattern.
   (c) Both patterns result from two slits.
   (d) Both patterns result from a single slit.



8. How many wavelengths farther is Point 1 from wave source S_2 than it is from wave source S_1?

   2.5λ

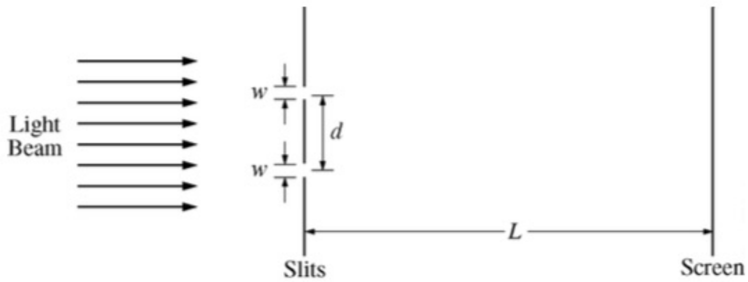
9. How many wavelengths farther is Point 2 from wave source S_2 than it is from wave source S_1?

   1λ

10. How many wavelengths farther is Point 3 from wave source S_1 than it is from wave source S_2?

    $\frac{1}{2}\lambda$

11. In a classroom experiment a green laser with a wavelength of 532 nm is aimed at a pair of narrow, parallel slits in an otherwise opaque film. Each slit has a width $w = 1.0$ μm. The distance between the two slits is 2.0×10^{-5} m. You observe bright and dark fringes on a screen that is $L = 4.5$ m from the slits. Your notebook shows the following diagram for the experimental setup.



Note: Figure not drawn to scale.

(a) Calculate the distance between two consecutive dark fringes in the observed pattern.

The distance between consecutive dark fringes (nodes) is the same as the distance between consecutive bright fringes (antinodes). One *could* calculate the positions of the first and second antinode and subtract them to get the answer, but instead I will just calculate the location of the first order bright fringe; it will be one fringe space from the central antinode, and that will be the spacing that is our desired answer. For the first order bright fringe the path difference from the fringe to a grating slit and to its neighboring slit is 1 λ.

$$\frac{\lambda}{d} \approx \frac{x}{L}$$

$$\frac{5.32 \times 10^{-7}\ \text{m}}{2.0 \times 10^{-5}\ \text{m}} \approx \frac{x}{4.5\ \text{m}}$$

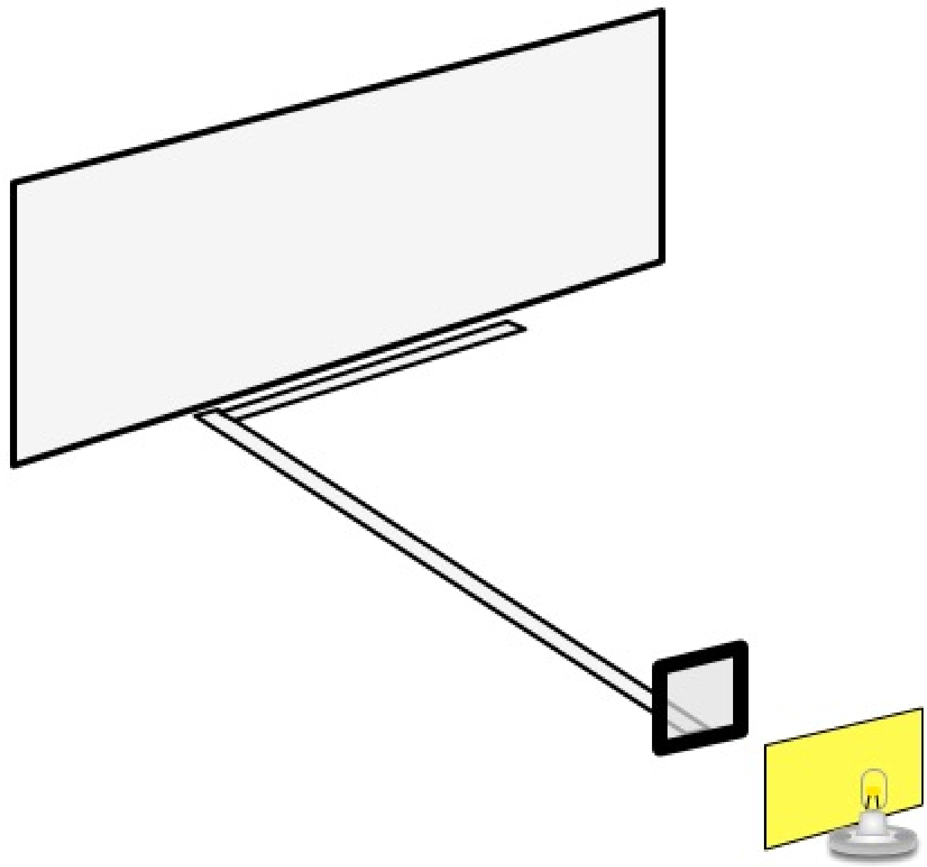
$x = 12$ cm

(b) Calculate the frequency of the light.

$v = f\lambda$ or in this case for light speed, 3.00×10^{8} m/s $= f(5.32 \times 10^{-7}$ m)

5.6×10^{14} Hz

12.



A lamp with a tiny filament shines through a yellow filter and then through a diffraction grating with its lines ruled in the vertical direction. The grating is held at one end of a meter stick which is aligned with the lamp. At the other end of the meter stick, a second rule is placed at right angles to the first rule.

(a) Student A asks student B to measure the distance to the first yellow spot from the central bright yellow spot on the screen. If the distance is x = 0.37 m and the diffraction grating has 6.0×10^5 lines per meter, calculate the wavelength of the yellow light.

I will use the distance x of the first order bright spot from the central maximum. The difference in distance from the first order bright spot to one particular grating slit and the distance from that spot to a neighboring grating slit is 1 λ.

$$d = \frac{1}{6.0 \times 10^5 \text{ m}^{-1}} = 1.67 \times 10^{-6} \text{ m}$$
$$\frac{x}{L} = \tan\theta \Rightarrow \frac{0.37 \text{ m}}{1.0 \text{ m}} = \tan\theta \Rightarrow \theta = 20.3^\circ$$
$$\frac{\lambda}{d} = \sin\theta \Rightarrow \lambda = d\sin\theta \Rightarrow \lambda = 1.67 \times 10^{-6} \text{ m} \cdot \sin 20.3^\circ = 592 \text{ nm}$$

(b) How many more yellow spots will there be to the right of this bright yellow spot? Explain.

There will be one more bright yellow spot to right, because the bright spot will be at a location that is two wavelengths (1184 nm) farther from one particular slit than its neighboring slit. That is possible, because the slits are 1670 nm apart. There will be no third bright spot, however. It is impossible to be 3λ farther from a particular slit and its neighboring slit for this grating.

(c) If the filter is removed, sketch the full pattern seen on both sides of the central bright spot, in the space below. Label significant features.