Early Booklet E.C.:	**+ 1**
Unit 5.C Hwk. Pts.:	**/ 25**
Unit 5.C Lab Pts.:	**/ 20**
Late, Incomplete, No Work, No Units **Fees**?	Y / N

Unit 5.C – Physical Optics

Essential Fundamentals of Physical Optics

1. Light reflects with a 0° shift when entering a medium of lower optical density, and with a 180° shift when entering one of higher optical density.
2. When traveling between media of different optical density, the frequency of light is unchanged, but speed and wavelength change.
3. Constructive interference involves adding intensity, and destructive subtracts light intensity.
4. Frequency and slit width influence interference patterns.
5. Polarization involves light having electric and magnetic fields oriented in the same direction.
6. The minimum thickness that a film will undergo interference is ¼ of an adjusted wavelength.
7. Transmission is a measure of how much light is allowed through a material.

Equation Sandbox

In Unit 5.C, some of the following equations will be used. Practice isolating variables to prepare for it.

Diffraction Minima Location
$$y_m = \frac{mL\lambda}{d}$$
$m =$

$L =$

$\lambda =$

$d =$

Index of Refraction
$$n = \frac{c}{v}$$
$v =$

EM Wave Equation
$$c = \lambda f$$
$\lambda =$

$f =$

Diffractrion Equation
$$d\sin\theta = m\lambda$$
$d =$

$m =$

$\lambda =$

$\theta =$

Double-Slit Destructive Interference
$$d\sin\theta = \frac{m\lambda}{2}$$
$d =$

$m =$

$\lambda =$

$\theta =$

Minimum Thickness
$$t_{\min} = \frac{\lambda'}{4}$$
λ'

Grating Maxima
$$\frac{\sin\theta}{N} = n\lambda$$
$N =$

$n =$

$\lambda =$

$\theta =$

Waves vs. Length
$$\Delta L = m\lambda$$
$m =$

$\lambda =$

Thickness vs. Path
$$\Delta L = 2t$$
$t =$

Double-Slit Constructive Interference
$$d\sin\theta = m\lambda$$
$d =$

$m =$

$\lambda =$

$\theta =$

Intensity Equation
$$I = I_0 \cos^2\theta$$
$I_0 =$

$\theta =$

Wavelength in Medium
$$\lambda' = \frac{\lambda}{n}$$
$n =$

$\lambda =$

AP Equations

In-Class Equations

Brewster's Angle
$$\theta_p = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$
$n_1 =$

$n_2 =$

Transmission Equation
$$\%T = \frac{I}{I_0} \bullet 100\%$$
$I =$

$I_0 =$

Central Max. Eq.
$$2y_1 = \frac{2L\lambda}{d}$$
$L =$

$d =$

$\lambda =$

Possible 5.C.1 Pts.: 6	
Late, Incomplete, No work, No Units Fee: - 1 - 2	
Final Score:	**/ 6**

5.C.1 Problems – Young's Double Slit Experiment
Section 24.1 of your textbook.

1. To study wave interference, a student uses two speakers driven by the same sound wave of wavelength 0.50 m. If the distances from a point to the speakers differ by 0.75 m, will the waves interfere constructively or destructively at that point? What if the distances differ by 1.0 m?

2. In the development of Young's double slit experiment, a small-angle approximation ($\tan\theta = \sin\theta$) was used to find the lateral displacement of the maxima (bright) and minima (dark) positions. How good is this approximation? For example, what is the error if $\theta = 10°$?

3. When two parallel slits are illuminated with monochromatic light of wavelength of 632.8 nm, the angle between the center of the central maximum and the center of the second side maximum is 0.45°. What is the distance between the parallel sits?

4. If the wavelength used in a double-slit experiment is decreased:
   A. The distance between adjacent maxima will (1) increase, (2) decrease, (3) remain the same. Explain.

   B. If the separation between the two slits is 0.20 mm and the adjacent maxima of the interference pattern on a screen 1.5 m away from the slits are 0.45 cm apart, what is the wavelength and color of the light?

   C. If the wavelength is 550 nm, what is the distance between adjacent maxima?

Possible 5.C.2 Pts.: 8			
Late, Incomplete, No work, No Units Fee:	- 1	- 2	-3
Final Score:	/ 8		

5.C.2 Problems – Thin Film Interference

Section 24.2 of your textbook.

1. Light of wavelength 550 nm in air is normally incident on a glass plate (n = 1.5) whose thickness is 1.1 E -5 m.
   A. How many oscillations would a light wave undergo as it passed through the glass?

   B. How many reflected waves will experience the 180° phase shift?

   C. Will the reflected waves interfere constructively or destructively? Explain.

2. A film of index of refraction of 1.4 and a thickness of 1.2 E -5 m is on a lens with an index of refraction of 1.6. Light of wavelength 600 nm is incident normally from air to the film. Consider only reflections from the top and bottom surfaces of the film.
   A. How many reflected waves will experience the 180° phase shift? Explain.

   B. What is the path length difference between the two reflected waves?

   C. Will the reflected waves interfere constructively or destructively?

3. A film on a lens with an index of refraction of 1.5 is 1.0 E -7 m thick and is illuminated with white light. The index of refraction of the film is 1.4.
   A. The number of waves that experience the 180° phase shift is (1) zero, (2) one, (3) two. Explain.

   B. For what wavelength of visible light will the lens be nonreflecting?

Possible 5.C.3 Pts.: 5	
Late, Incomplete, No work, No Units Fee:	- 1 - 2
Final Score:	/ 5

5.C.3 Problems – Diffraction
Section 24.3 of your textbook.

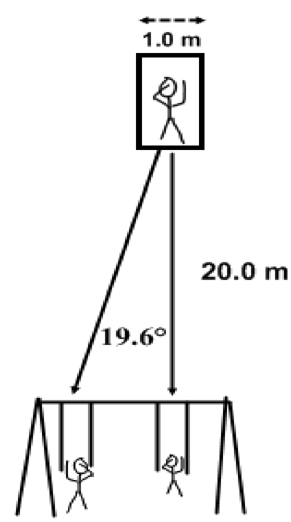
1. A slit of width 0.15 mm is illuminated with monochromatic light of wavelength 632.8 nm. At what angle will the first minimum occur?

2. In a single-slit diffraction pattern using light of wavelength 550 nm, the second-order minimum is measured to be at 0.32°. What is the slit width?

3. A venetian blind is essentially a diffraction grating, not for visible light, but for waves with much longer wavelengths. If the spacing between the slats of a blind is 2.5 cm:
   A. For what wavelength would there be a first-order maximum at an angle of 10°?

   B. What type of radiation is this?

4. A teacher standing in a doorway 1.0 m wide blows a whistle with a frequency of 1000 Hz to summon children from the playground. Two boys are playing on swings 20.0 m away from the school building. One boy is at an angle of 0.0° and another one is at 19.6° from a line normal to the doorway. Taking the speed of sound in air to be 335 m/s, which boy may not hear the whistle? Prove your answer.



Possible 5.C.4 Pts.: 6
Late, Incomplete, No work, No Units Fee: - 1 - 2
Final Score: / 6

5.C.4 Problems – Polarization & Scattering
Section 24.4–24.5 of your textbook.

1. Unpolarized light is incident on a polarizer-analyzer pair that can have their transmission axes at an angle of either 30° or 45°. Answer the next two questions.
   A. The 30° angle will allow (1) more, (2) the same, (3) less light to go through. Explain.

   B. Calculate the percentage of light that goes through the polarizer-analyzer pair in terms of the incident light intensity.

2. Some types of glass have a range of indices of refraction of about 1.4 to 1.7. What is the range of the polarizing (Brewster) angle for these glasses when light is incident on them from air?

3. Light is incident on a certain material in air.
   A. If the index of refraction of the material increases, the polarizing (Brewster) angle will (1) also increase, (2) decrease, (3) remain the same. Explain.

   B. What are the polarizing angles if the index of refraction is 1.6 and 1.8?

4. A beam of light is incident on a glass plate (n = 1.62) in air and the reflected ray is completely polarized. What is the angle of refraction for the beam?

AP Physics 2	Unit 5.C.1 Lab - Laser Diffraction Patterns	
Reminder: Update Table of Contents		Correction Credit: Half

Diffraction Lab (5.C.1) Guide		
Table of Contents, Title/Date, Complete Synopsis, Two Purposes, Legible		/ 2
Mission 1: Data Table: Diffraction Through Slit	Space b/w maxima	/ 2
	Laser to caliper dist.	/ 1
	Caliper/screen dist.	/ 1
	Slit widths	/ 2
M. 2: Hole Diffraction	Data table present	/ 1
	Space b/w maxima	/ 1
Analysis 1: Calculated wavelengths of your laser, and average.		/ 3
		/ 1
Analysis 2: Calculated diameter of hole in paper.		/ 2
Q. 1: Laser wavelength comparison.		/ 2
Q. 2: Diffraction pattern differences.		/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee:		-4
Total:		**/ 20**

<u>Lab Overview:</u>

In this lab, there is one set of equipment, so everyone will have the same data set as we work on it together. We will be using a laser, shone through different narrow apertures, to determine the wavelength of a red laser.

<u>Materials List:</u>

Red, Blue, or Green Laser
Caliper
Meter sticks
Standardized testing ruler
Paper with hole in it

<u>Mission 1:</u> Record all values in the same data table.

Shine your laser through a narrow slit caliper, and measure the interference pattern spacing between maxima. Record distance from laser to caliper, caliper to screen, and slit width of caliper in a data table.

Alter the caliper slit width twice more and repeat measurements, using the same data table.

<u>Mission 2:</u> Record all values in a data table.

Shine your laser through a small hole in a piece of paper and measure the interference pattern spacing between maxima. Record bright fringe spacing in a new data table. The distances from laser to paper, and paper to screen will be the same as in Mission 1, but record them in the table.

<u>Analysis:</u> Answer these completely in your Lab Books , showing all work.

1. Using your data in Mission 1, calculate the exact wavelength of your laser light for all three slit widths, then record the average of the three.

2. Using the previous calculation and data from Mission 2, calculate the diameter of the hole in the piece of paper.

<u>Questions</u>: Rephrase and answer each in at least <u>three complete sentences</u> for full credit.

1. How do your laser light wavelength calculations compare for the three different slit widths in Mission 1?

2. Describe the differences in diffraction pattern appearances between Mission 1 and Mission 2. Explain what accounts for the differences.

AP Physics 2	Unit 5.C - Physical Optics				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

Your grade on this problem set depends on the presentation you provide for your assigned problems, and whether **all** problems are complete when you submit your Booklet at the end of the Unit.

Application Problems

1. In a double-slit experiment that uses monochromatic light, the angular separation between the central maximum and the second order maximum is 0.160°. What is the wavelength of the light if the distance between the slits is 0.350 mm?

2. Light of wavelength 0.50 μm illuminates a soap film (n = 1.33). What is the minimum thickness of film that will give an interference when the light is incident normally on it?

3. A soap bubble has an index of refraction of 1.33. What minimum thickness of this bubble will ensure maximum absorbance of normally incident 425 nm wavelength light?

4. A single-slit experiment uses light of wavelength 720. nm with a slit separation of 0.250 mm and a screen placed 2.7 m away.
   A. What is the linear width of the central fringe on the screen?

   B. What is the linear distance on the screen between the central maximum and the 1st order maximum?

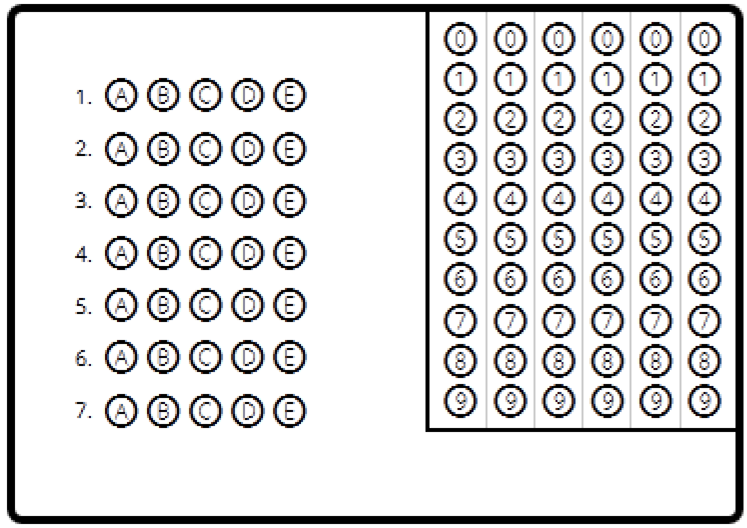
AP Multiple Choice Question

5. In Young's double-slit interference experiment, what is the difference in path length of the light waves from the two slits at the center of the first bright fringe above the central maximum?

A. 0 B. ¼ λ C. ½ λ D. λ E. 3/2 λ

AP Physics 2		Unit 5.C Review - Physical Optics					
Points:	/ 14	Late or Incomplete Fee:	-2 -4 -6	Correction Credit:		Final Score:	

Each question is worth two points.



1. Two parallel slits 0.075 mm apart are illuminated with monochromatic light of wavelength 480 nm. Find the angle between the center of the central maximum and the center of the first side maximum.

A. 0.083° B. 0.14° C. 0.22°
D. 0.37° E. 0.42°

2. 550. nm light passes through two narrow slits 2.10 μm apart. The 1st and 2nd order bright fringes are 1.00 mm apart on a distant screen. How far apart are the 2nd and 3rd order bright fringes?

A. 1.00 mm B. 1.35 mm C. 1.74 mm
D. 0.75 mm E. 0.50 mm

3. A slit of width 0.20 mm is illuminated with monochromatic light of wavelength of 480 nm, and a diffraction pattern is formed on a screen 1.0 m from the slit. What is the width of the central maximum?

A. 2.4 E -3 m B. 4.8 E -3 m C. 5.6 E -3 m D. 8.2 E -3 m E. 9.1 E -3 m

4. A 0.20 mm wide slit is illuminated with 480 nm monochromatic light, and a diffraction pattern forms on a screen 1.0 m from the slit. What is the width of the second-order maximum?

A. 2.4 E -3 m B. 4.8 E -3 m C. 5.6 E -3 m D. 8.2 E -3 m E. 9.1 E -3 m

5. Consider an oil film (n = 1.50) on water (n = 1.33) and 600 nm incident light. The minimum film thickness for constructive interference is

A. 200 nm B. 150 nm C. 50 nm D. 113 nm E. 100 nm

6. A lens with an index of refraction of 1.60 is to be coated with a material (n = 1.40) that will make the lens nonreflecting for yellow-orange light (λ = 515 nm) normally incident on the lens. What is the minimum required thickness of the coating?

A. 6.29 E -8 m B. 9.20 E -8 m C. 4.12 E -8 m D. 7.33 E -8 m E. 4.6 E -8 m

7. Light which reflects off a pond of water undergoes a phase shift of

A. 90° B. 270° C. 0° D. 180° E. 45°