Early Booklet E.C.:	**+ 1**
Unit 5.A Hwk. Pts.:	**/ 18**
Unit 5.A Lab Pts.:	**/ 18**
Late, Incomplete, No Work, No Units **Fees**?	Y / N

Unit 5.A – Properties of Light

Essential Fundamentals of Light

1. Electromagnetic radiation has oscillating magnetic and electric components.
2. As a wave travels from one medium to another, frequency does not change, but wavelength and wave speed do.
3. The wave equation unifies wave speed, wavelength, and frequency.
4. When passing from a material of lower optical density, to one of higher optical density, light will bend towards the normal.
5. In a vacuum, all electromagnetic radiation travels at the speed of light: 3.0 E 8 m/s.
6. Index of refraction is a measure of optical density: the higher the index, the greater the optical density.
7. Dispersion occurs when different frequencies of light bend differently as they pass through one medium to another.
8. Reflection of light occurs when light 'bounces' off a surface, refraction occurs when light 'bends' at the junction between two materials.
9. The angle of incidence is measured with respect to the normal, perpendicular to a material's surface.

Equation Sandbox

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

AP Equations

In-Class Equations

General Wave Equation

$$\lambda = \frac{v}{f}$$

$f =$

$v =$

EM Wave Equation

$$c = \lambda f$$

$\lambda =$

$f =$

Snell's Law

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

$n_1 =$

$\theta_1 =$

n_2

$\theta_2 =$

$$\theta_i = \theta_r$$

EM Power vs. Distance

$$\frac{P_1}{P_2} = \frac{r_1^2}{r_2^2}$$

$P_1 =$

$P_2 =$

$r_1 =$

$r_2 =$

Refractive Index Definition

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

$v =$

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

5.A.1 Problems – Electromagnetic Waves

Section 20.4 of your textbook.

1. How long does a laser beam take to travel from the Earth to a reflector on the Moon and back? The distance from the Earth to the Moon is 3.63 E 5 km.

2. Orange light has a wavelength of 600 nm; green has a wavelength of 510 nm.
   A. What is the difference in frequency between the two types of light?

   B. If you doubled the wavelength of both, what type of light would they become?

3. If the power of a radiation source measured 1.4 E -6 W/m^2, at 1.0 meters distance, what would the power be at 2.3 meters distance? How about at 4.0 meters distance?

4. What is the wavelength of radiation that has a frequency of 3.5 E -11 Hz? What type of radiation is this?

5. What is the wavelength of a radiation type with a frequency of 4.5 E 6 Hz? What is a physical object with this wavelength?

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

5.A.2 Problems – Reflection
Section 22.1 – 22.2 of your textbook.

1. A beam of light is incident on a plane mirror at an angle of 25^o relative to the normal. What is the angle between the reflected ray and the surface of the mirror?

2. A beam of light is incident on a plane mirror at an angle α relative to the surface of the mirror.
   A. Will the angle between the reflected ray and the normal be (1) α, (2) $90^o - \alpha$, or (3) 2α? Explain.

   B. If $\alpha = 33^o$, what is the angle between the reflected ray and the normal?

3. When you see the Sun over a lake or ocean, you often observe a long swath of light. What causes this effect, sometimes called a glitter path?

4. Draw a ray diagram of an object in a mirror (like a key), so that it is apparent why we see the key being laterally inverted.

5. What would a mirror's image be, if instead of being polished to irregularities less than 100 nm, it were only polished to irregularities of 550 nm, which extends to the green part of the visible spectrum (some research as to what wavelengths we can see might help)?

Possible 5.A.3 Pts.: 6
Late, Incomplete, No work, No Units Fee: - 1 - 2
Final Score: / 6

5.A.3 Problems – Refraction, Optical Phenomena

Section 22.3 – 22.5 of your textbook.

1. The index of refraction in a certain precious transparent stone is 2.35. What is the speed of light in that stone?

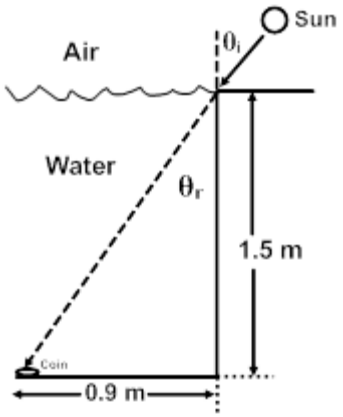
2. Light passes from a crown glass container into water.

A. Will the angle of refraction be (1) greater than, (2) equal to, or (3) less than the angle of incidence? Explain.

B. If the angle of refraction is 20^o, what is the angle of incidence?

3. What is the critical angle of a diamond in water?

4. A coin lies on the bottom of a pool under 1.5 m of water and 0.90 m from the side wall. If a light beam is incident on the water surface at the wall, at what angle θ relative to the wall must the beam be directed so that it will illuminate the coin?



5. White light is incident from air onto a transparent material at an angle of incidence of 40^o. The angles of refraction for the red and blue colors are 28.15^o and 27.95^o, respectively. What are the indices of refraction for the two colors?

AP Physics 2	Unit 5.A.1 Lab - Refractive Index of Water
Reminder: Update Table of Contents	Correction Credit: Half

Lab Overview:

You and your team will measure the refractive index of water, and compare your value to the accepted value.

Materials List:

Protractors
Laser
Rulers
Fish Tank
Corn Starchy Water

Refractive Index Lab (5.A.1) Guide		
Table of Contents, Title/Date, Complete Synopsis, Two Purposes, Legible		/ 2
Mission 1: Data Table	Present	/ 1
	Well-organized	/ 1
	Three Angles	/ 3
Analysis 1: Three index calculations.		/ 3
Analysis 2: Average index.		/ 1
Analysis 3: Index percent error.		/ 1
Q. 1: Describe your data collection method and include diagrams.		/ 3
		/ 1
Q. 2: What could reduce error?		/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee:		-3
Total:		/ 18

Mission 1: Refractive Index of Water

Devise a method to measure light's refraction through water at three different angles of incidence, as measured from the top of the water (not through the glass sides). I recommend using angles that are between five and ten degrees apart.

At each angle of incidence, measure the corresponding angle of refraction and record it in a well-organized data table in your lab booklet.

Analysis: Index Calculations.

1. Calculate the index of refraction for each of the three angles from Mission 1. Show all work for full credit. Use 1.00 as the value of air's index of refraction when performing calculations.

2. Determine and report the average of the three different values.

3. Using the accepted index of refraction for water, determine the percent error (Equation in Resources) of your average value.

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

1. Describe the exact method by which you and your partners obtained your raw data, including diagrams of your setup.

2. What could be done better to reduce your percent error?

AP Physics 2	Unit 5.A - Light, Reflection, Refraction				
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. Light passes from air into water at an angle of incidence of 12.3º. What is the angle of refraction in the water?

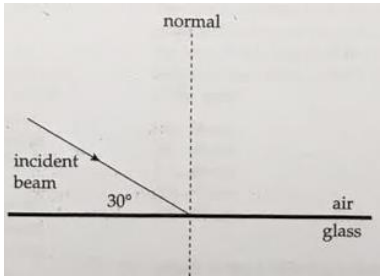
2. The index of refraction for crown glass is 1.52. That of vegetable oil is 1.41. If light is passing out of glass into oil, what is critical angle at which it will be entirely reflected?

AP Multiple Choice Questions

1. What is the wavelength of an X-ray whose frequency is 1.0 E 18 Hz?

A. 3.3 E -11 m B. 3.0 E -10 m C. 3.3 E -9 m D. 3.0 E -8 m E. 3.0 E 26 m

2. A beam of light in air is incident upon the smooth surface of a piece of flint glass, as shown. If the reflected beam and refracted beam are perpendicular to each other, what is the index of refraction of the glass?



A. ½ B. ½ $(3)^{½}$ C. $(3)^{½}$ D. 2 E. 2 $(3)^{½}$

3. When green light (wavelength = 500 nm in air) travels through diamond (refractive index = 2.5), what is its wavelength?

A. 200 nm B. 300 nm C. 500 nm D. 1000 nm E. 1250 nm

4. A beam of light traveling in Medium 1 strikes the interface to another transparent medium, Medium 2. If the speed of light is less in Medium 2 than in Medium 1, the beam will

A. Refract toward the normal B. Refract away from the normal
C. Undergo total internal reflection
D. Have an angle of reflection smaller than the angle of incidence
E. Have an angle of reflection greater than the angle of incidence

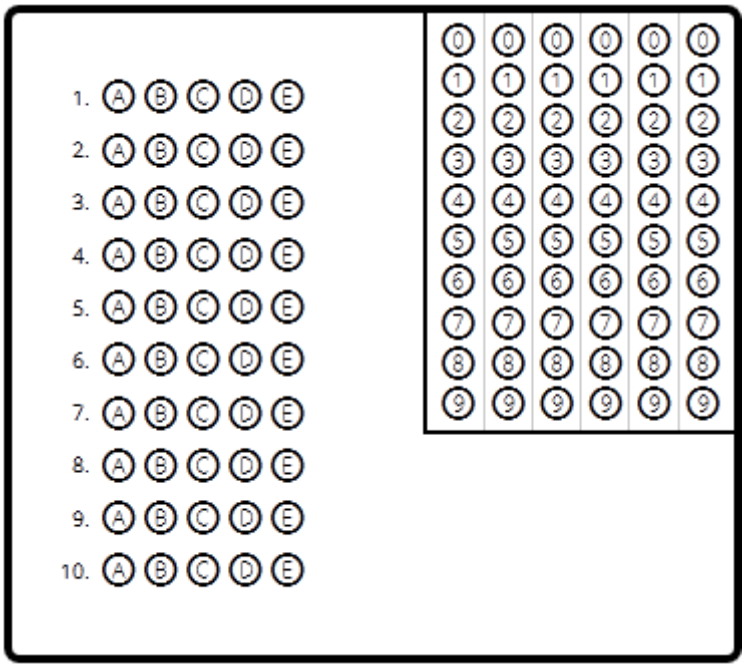
5. If a clear liquid has a refractive index of 1.45 and a transparent solid has an index of 2.90 then, for total internal reflection to occur at the interface between these two media, which of the following must be true?

Incident beam originates in	At an angle of incidence greater than
a) The solid	30 degrees
b) The liquid	30 degrees
c) The solid	60 degrees
d) The liquid	60 degrees
e) Total internal reflection cannot occur	

AP Physics 2		Unit 5.A Review - Light, Reflection, Refraction					
Points:	/ 20	Late or Incomplete Fee:	-2 -4 -6	Correction Credit:		Final Score:	

Solve these problems here, THEN enter your responses in the bubble sheet provided.

Each question is worth two points.



1. A microwave oven produces EM radiation at a frequency of 3.24 E 10 Hz. What is the wavelength of this radiation?

A. 9.3 E -3 m B. 8.0 E -3 m
C. 6.6 E -3 m D. 4.8 E -3 m
E. 2.3 E -3 m

2. An EM wave has a wavelength of 62.0 m. What's the frequency of this radiation?

A. 1.2 E 6 Hz B. 2.5 E 6 Hz C. 3.6 E 6 Hz D. 4.2 E 6 Hz E. 4.8 E 6 Hz

3. In an alternate universe, EM radiation travels differently. If one form of EM radiation has a frequency of 5.6 E 9 Hz, and a corresponding wavelength of 2.8 m, what would the speed of light be there?

A. 5.0 E -10 m/s B. 3.0 E 8 m/s C. 2.0 E 9 m/s D. 1.6 E 10 m/s E. 3.2 E 10 m/s

4. Describe how a desert mirage works – where the sky is seen as a pool of water on the ground in the distance.

A. Light bends downwards as it passes from a low density air mass to a high density one.
B. Light bends upwards as it passes from a high density air mass to a low density one.
C. Light bends upwards as it passes from a low density air mass to a high density one.
D. Light bends downwards as it passes from a high density air mass to a low density one.

5. You are standing between the sun and your house on a clear summer morning, and the sun is at 40° above the horizon. If you were to reflect sunlight into your lazy brother's room to wake him up, at what angle (with respect to horizontal) would you have to hold the mirror to do so? From your position, the light beam will have to be directed at an angle 70° above the horizontal to get into his room.

A. 15° B. 30° C. 35° D. 40° E. 70°

6. The power of a light source is 24 W/m^2 when measured 1.0 m from the source. What will the power measurement be 2.0 m away from the source?

A. 6.0 W/m^2 B. 12 W/m^2 C. 3.0 W/m^2 D. 1.5 W/m^2 E. 4.5 W/m^2

7. The power of a light source is 24 W/m^2 when measured 1.0 m from the source. What will the power measurement be 4.0 m away from the source?

A. 6.0 W/m^2 B. 12 W/m^2 C. 3.0 W/m^2 D. 1.5 W/m^2 E. 4.5 W/m^2

8. A light beam 14.0º from the normal inside a diamond strikes the diamond-air boundary and emerges into the air. What is the refracted angle of the light beam as it enters the air?

A. 25.3° B. 28.7° C. 33.7° D. 35.8° E. 39.0°

9. A beam of light originating underwater approaches the surface at an incident angle of 43.0º. What is the critical angle of the water-air boundary?

A. 35.2° B. 43.8° C. 52.1° D. 48.8° E. 62.6°

10. A beam of light originating underwater approaches the surface at an incident angle of 43.0º. When the beam passes out of the water, what is the angle of refraction as it emerges into the air?

A. 58.9° B. 63.4° C. 65.1° D. 67.2° E. 69.0°