PHYS 2112; Spring 2019 **Exam 3** **April 2, 2019**

Last Name (print)_____ **First Name** (print)_____

Signature _____ LSUID No. _____

TURN OFF AND PUT AWAY ANY AND ALL NONAPPROVED ELECTRONIC DEVICES.

Have your LSU ID ready when you turn in your paper.

You may only use an ordinary scientific or graphing calculator. *You may not use a cell phone, smart phone, or tablet application as your calculator.*

Examine your paper to be sure it is complete and legible. There should be 13 multiple-choice questions and 2 free-response problems points. There are 7 pages, including the cover sheet.

Circle one:

MWF 11:30 am (S. Marley)

MWF 1:30 pm (M. Gaarde)

TTh 9:00 am (P. Sprunger)

For the multiple choice questions, bubble in the correct answer on your ScanTron for each question. There is room on the exam for scratch work or calculations, but that work will not be checked or graded. Partial credit may be awarded on multiple-choice questions, but this partial credit will be based on the answers that you have bubbled in on the ScanTron and NOT on your scratch work on the exam itself.

For the free-response problems, show all relevant work in the space provided. Without supporting work, even a correct answer will receive little or no credit. Partial credit will be awarded as warranted. If your work for a problem is somewhere other than the space provided for that part of the problem, you must indicate where your work is located. For example, if you need more room for your solution, then you may write on the back of the page. Be sure to add a note to this effect; otherwise, anything on the back of the paper will be regarded as scratch work and will not be checked or graded.

Be sure that numerical answers appear with appropriate **SI units**. Points will be deducted for missing, incorrect, or "silly" units. In addition, you must carry the units through each calculation – it is not enough to just stick the correct units onto your final answer. If the final answer is, in fact, a dimensionless quantity, please write the numerical result followed by the word dimensionless.

You will have 60 minutes to complete this examination.

➔ ***Your free response will be graded for consistency. That is, if you need a quantity from a previous part and didn't get it right or could not complete it, you will be graded on your work for the part you are working on.***

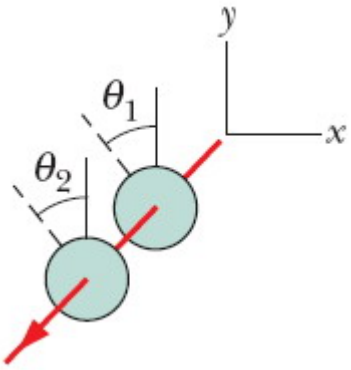
Question #1 (no points) Bubble in the answer choice corresponding to your class section number.

A. Sec. 1; MWF 11:30 am (S. Marley)
B. Sec. 2; MWF 1:30 pm (M. Gaarde)
C. Sec. 3; TuTh 9:00 am (P. Sprunger)

Question #2 (no points)
Your version of the test is **A**. Bubble in answer **A** on your ScanTron.

Question #3 (5 points)

A beam of initially unpolarized light travels through two polarizing sheets, with polarizing directions given by the angles θ_1=52º and θ_2=90º, measured from the y-axis as shown in the figure (note: angles not drawn to scale). Given the initial light intensity of 26.2 W/m^2 what is the intensity of the transmitted light?



(A) 6.2 W/m^2
(B) 19.6 W/m^2
(C) 16.3 W/m^2
(D) 2.2 W/m^2
(E) 8.1 W/m^2

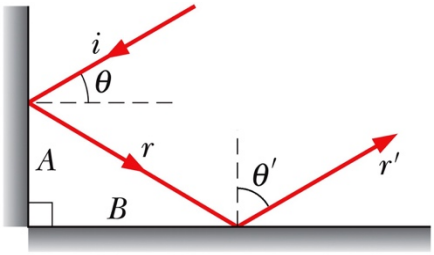
Question #4 (5 points)

Assume (unrealistically) that a TV station acts as a point source broadcasting isotropically at 55 MW. What is the intensity of the transmitted signal reaching Alpha Centari, the closest star to our Sun, that is 4.3 ly away. A light-year (ly) is the distance light travels in one year (1 year $\cong \pi \times 10^7$ sec)

A) 6.7×10^{-28} W/m^2
B) 2.7×10^{-27} W/m^2
C) 6.7×10^{-37} W/m^2
D) 2.7×10^{-36} W/m^2
E) 6.7×10^{-31} W/m^2

Question #5 (5 points)

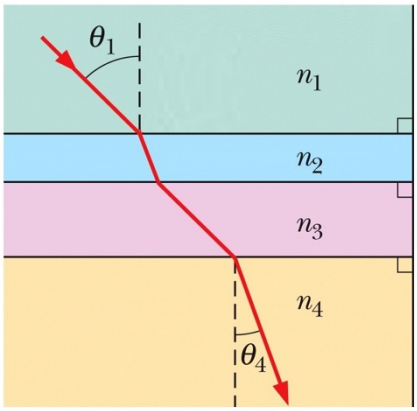
Mirror A and mirror B are arranged at right angles as shown in the drawing. Light ray i is incident on mirror A at an angle of $\theta = 40.0°$. At what angle θ' does the exiting ray r' leave mirror B?



(A) 20.0°
(B) 45.0°
(C) 40.0°
(D) 10.0°
(E) 50.0°

Question #6 (5 points)

In the figure (not to scale), light is incident at angle $\theta_1 = 40°$ on a boundary between two transparent materials. The light travels down through the next three layers of transparent materials. If $n_1 = 1.20$, $n_2 = 1.80$, $n_3 = 1.40$, and $n_4 = 1.60$, what is the value of angle θ_4?



(A) 25.37°
(B) 33.43°
(C) 28.82°
(D) 31.70°
(E) None of these.

Question #7 (5 points)

At a quiet pond with crystal clear water, you decide to fish with a bow and arrow. You see a fish swimming below the surface of the water. In order to hit the fish with the arrow, you must:
(Note: a sketch may help you here)

(A) aim above the image of the fish.
(B) aim directly at the image of the fish.
(C) aim below the image of the fish.
(D) It depends on how large the fish is.
(E) It depends on how deep the pond is.

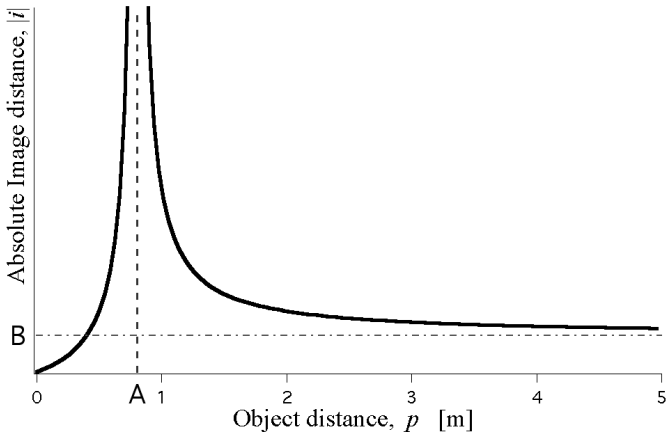
Question #8 (5 points)

A light ray is traveling in a diamond ($n = 2.419$). If the ray approaches the diamond-air interface, what is the minimum angle of incidence that will result in all of the light being reflected back into the diamond? The index of refraction for air is 1.000.

(A) 24.42°
(B) 32.46°
(C) 54.25°
(D) 65.58°
(E) 77.54°

Question #9 (5 points)

An object is placed against the center of a converging lens and then moved along the central axis until it is 5.0 m from the lens. During the motion, the distance $|i|$ between the lens and the image it produces is measured.



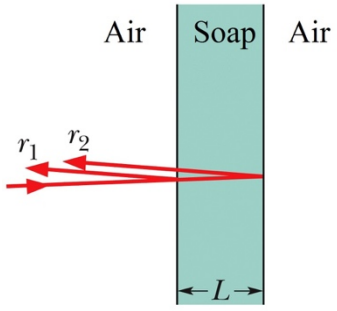
On the graph, what value of p is indicated by the dotted line *A*?

(A) $p = f$
(B) $p = 2f$
(C) $p = f/2$
(D) $p = |i|$
(E) None of these.

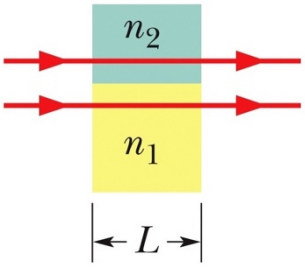
Question #10 (5 points)

Light of wavelength 610 nm is incident perpendicularly on a thin soap film ($n = 1.38$) that makes the wall of a soap bubble. (In the figure, the rays are tilted only for clarity.) What ***minimum*** thickness *L* of the soap film will result in constructive interference of the reflected rays r_1 and r_2?

(A) 222 nm
(B) 111 nm
(C) 0 nm
(D) 153 nm
(E) 305 nm



Question #11 (5 points)



In the figure, assume the two light waves, of wavelength 650 nm in air, are initially in phase. The indices of refraction of the two media are $n_1 = 1.31$ and $n_2 = 1.73$, and the media are both $L = 1.00$ μm thick.

What is the phase difference $\Delta\phi$ between the rays when they exit the two media?

(A) 0 rad
(B) 0.10 rad
(C) 0.65 rad
(D) 2.03 rad
(E) 4.06 rad

Question #12 (5 points)

If the distance between the slits in Young's two-slit experiment is decreased, which one of the following statements is true of the interference pattern?

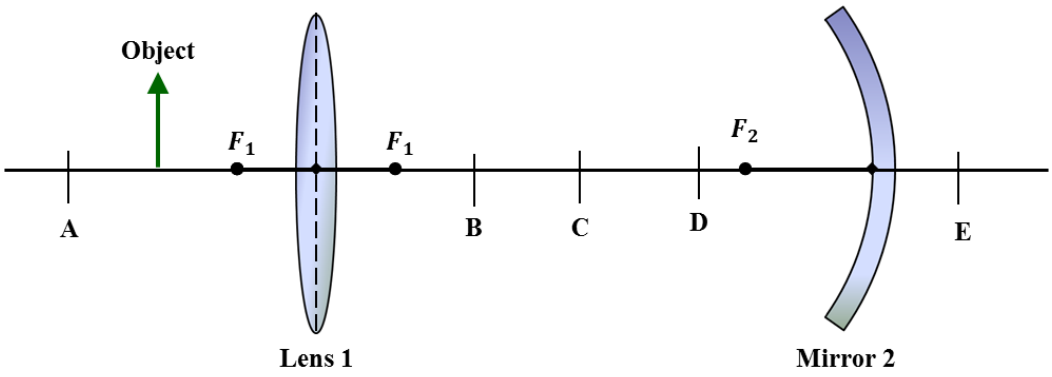
(A) The distance between the maxima stays the same.
(B) The distance between the maxima decreases.
(C) The distance between the minima stays the same.
(D) The distance between the minima increases.
(E) Impossible to tell without knowing the wavelength of light in use.

Question #13 (5 points)

The Hubble space telescope is in orbit around the earth. The aperture diameter of the telescope is 2.4 m. You are using the telescope to look at the cover of your physics textbook sitting on the surface of the earth. In red light (650 nm) Hubble can resolve the letters "P" and "s" in the word "Physics" on the cover. These two letters are separated by a distance of 16.5 cm. What is the height of Hubble's orbit? (Neglect the effects of earth's atmosphere.)

(A) 545 km
(B) 499×10^4 km
(C) 499 km
(D) 303×10^4 km
(E) 303 km

Problem #1 (24 points) – Show your work: An object is located to the left of a compound system consisting of a converging lens (lens 1) followed by a concave mirror (mirror 2). The focal lengths of the lens (F_1 = 2.1 cm) and mirror (F_2 = 3.4 cm) are labelled as shown. The distance from the object to the lens is 4.2 cm, and the distance from the lens to the mirror is 14.7 cm.



(a) (5 pts) Find the image distance i_1 for the intermediate image produced by only the lens.

(b) (7 pts) Calculate the image distance i_2 for the final image produced by Lens 1 and Mirror 2.

(c) (3 pts) Calculate the magnification of the final image:

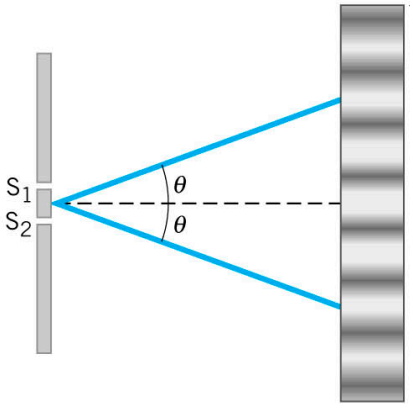
(c) (3 pts) Which of the positions A through E marked on the sketch is closest to i_2? (Circle the answer below)

A B C D E

(d) (6 pts) Use ray tracing to determine where the final image of the object will be located for the compound system. Your answer should be consistent with your answer in (b) and (c).

Problem #2 (20 Points) – Show your work!!!

In a double-slit experiment, the angle for the first interference side maximum is measured to be 0.0011 rad when light with wavelength 550 nm is used. The observation screen is placed 2.0 m from the slits.



(a) (4 pts) Calculate the separation between the two slits

(b) (6 pts) Calculate the location of the third interference side minimum on the screen, relative to the central axis:

(c) (6 pts) Calculate the width that each slit must have so that the first diffraction minimum exactly corresponds to the third interference side minimum discussed above.

(d) (4 pts) Describe in a few sentences and/or equations how the pattern on the screen would change if the whole apparatus were submerged in water (n = 1.33). Would both the diffraction and the double-slit patterns change?