Name: Sols ID: _____ Lab (day/time): _____

Physics 203
Midterm Exam 1
4/24/2019

Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating scientific calculator, 10 pages of scratch paper, writing utensils, a ruler, and the exam. You will have 80 minutes to complete this exam.

Constants:

$n_{air} = 1.00$, $n_{water} = 1.33$, $n_{glass} = 1.52$, $c = 2.998 \times 10^8$ m/s, $v_{sound} = 343$ m/s

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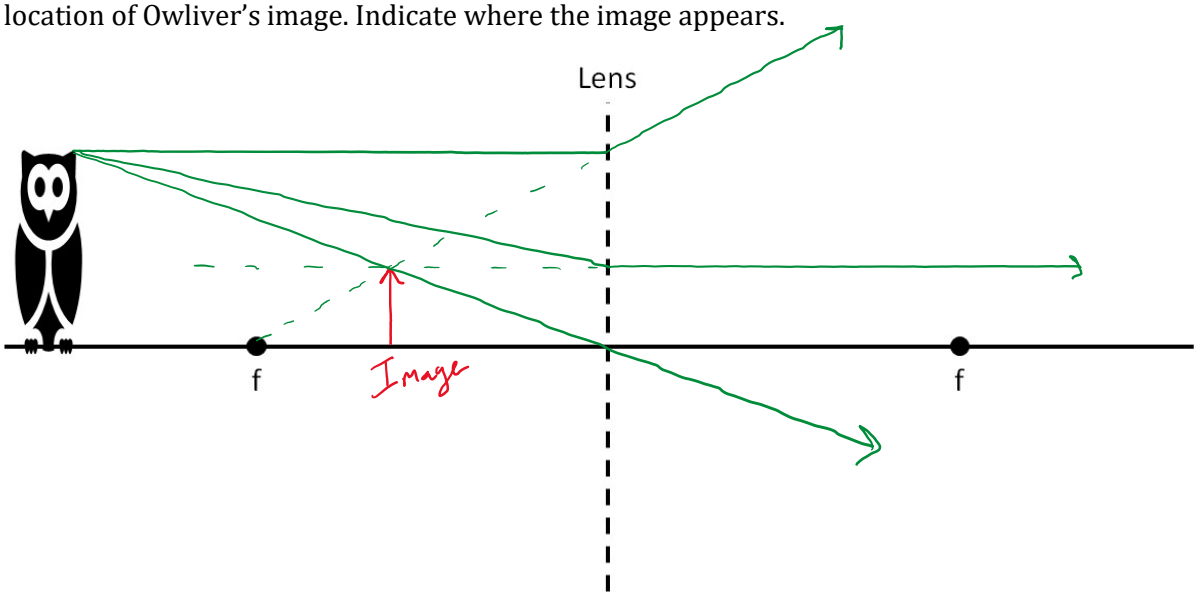
1. Owliver the barn owl is sitting as shown in front of a diverging lens with the pictured focal points.

(a) (4 points) Using the provided optical axis, carefully and precisely draw a ray diagram to find the location of Owliver's image. Indicate where the image appears.



(b) (1 points) Is the image real, or virtual?

Virtual (need to trace back)

(c) (1 points) Estimate the magnification of the image.

$m = +(<1)$ $\quad m \sim +\frac{2}{5}$

For questions 2 through 4 **fill in the square** next to all correct answers, a given problem may have more or less than one correct answer. Each correctly chosen answer will receive two points. There are **5 correct answers** in this section and only the first 5 filled in answers will be graded. There is no partial credit.

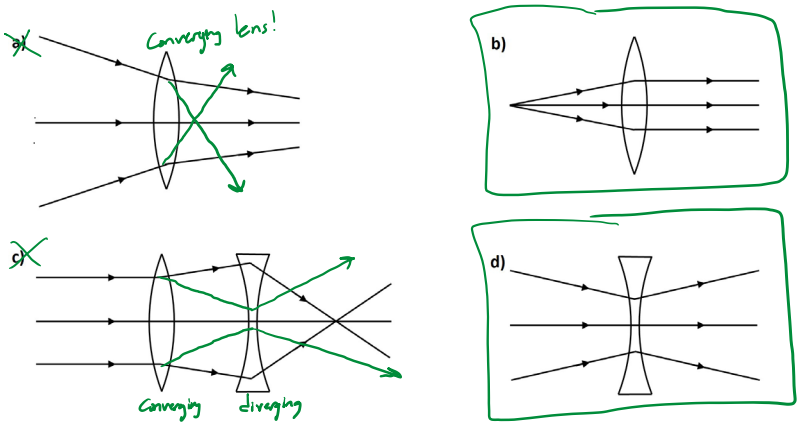
Which of the following are possible ray diagrams for the pictured lenses?

a)

b)

c)

d)

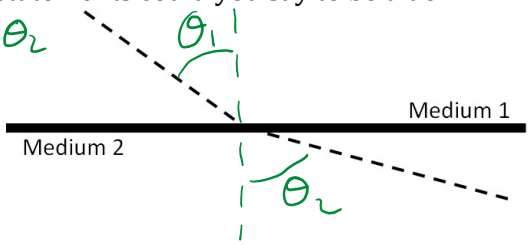


2. Light incident on an interface between two mediums follows the dashed path shown in the diagram. Which of the following statements could you say to be true?

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

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

$v = f\lambda$



$\theta_2 > \theta_1$

$n_2 < n_1$

$v_2 > v_1$

$\lambda_2 > \lambda_1$

a) Light travels faster in Medium 1 than Medium 2.

b) Light travels faster in Medium 2 than Medium 1.

c) Light travels the same speed in Medium 1 as in Medium 2.

d) The light has a longer wavelength in Medium 1 than in Medium 2.

e) The light has a shorter wavelength in Medium 1 than in Medium 2.

f) The light has the same wavelength in both mediums.

g) It is not possible to know the above unless we know which direction the light is traveling.

same both directions!

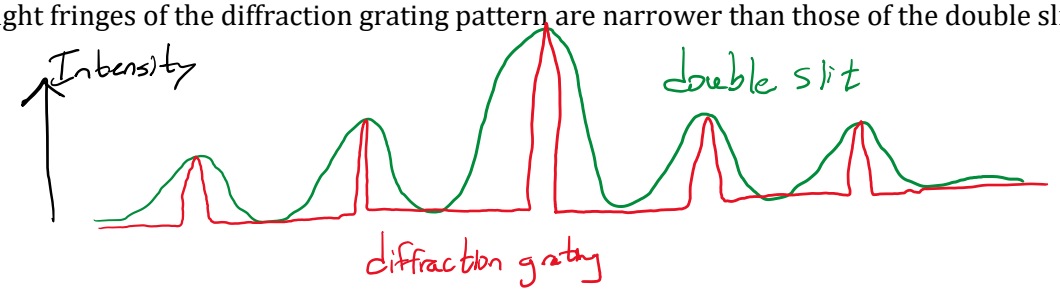
3. You shine identical lasers through diffraction grating and double slit apparatuses which have the same slit separation. Which of the following are true statements.

a) There are twice as many bright fringes in the double slit interference pattern.

b) There are more bright fringes visible in the diffraction grating interference pattern.

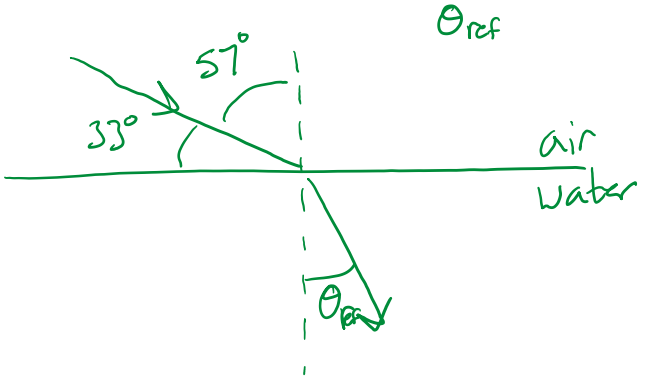
c) The two patterns look identical to each other.

d) The bright fringes of the diffraction grating pattern are narrower than those of the double slit.



4. Benny is LASER-fishing again (on a calm pond at sea level). Benny shines his high powered LASER from the air at an angle of 33° with respect to the surface of the water.

(a) (3 points) What is the refracted angle of the LASER light in the water?



θ_{ref}

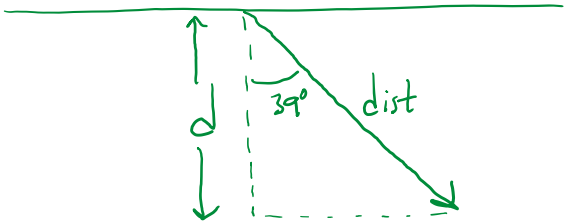
$1.00 \rightarrow n_{air} \sin(57°) = n_{water} \sin\theta_{ref}$ ($n_{water} = 1.33$)

$\Rightarrow \theta_{ref} = 39.1°$

or

0.63 rad

(b) (4 points) The LASER light, once it enters the water, takes 2.37 nanoseconds to reach the fish. What is the water pressure the fish feels?
(Hints: $P = P_0 + \rho g d$, $P_0 = 101{,}325\ Pa$, $g = 9.8\ m/s$, and $\rho_w = 1000\ kg/m^3$)



$dist = v\,\Delta t$

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

$\Delta t = 2.37 \times 10^{-9}$ sec

$\Rightarrow dist = 53.5$ cm

$\cos(39.1°) = \frac{d}{dist}$

$\Rightarrow d = (53.5\text{ cm})\cos(39.1°)$

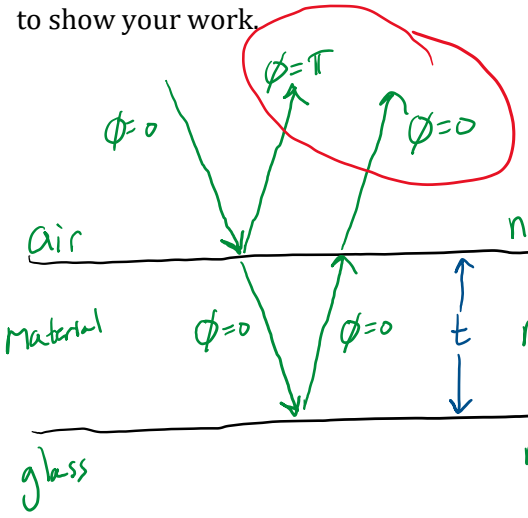
$d = 41.5$ cm

$P \simeq P_0 + \rho g d$

$P = 101{,}325\ Pa + 4{,}074\ Pa$

$\boxed{P = 105{,}400\ Pa}$

6. **(8 points)** Alexander Joseph (Lex) Luthor would like to create an anti-reflective coating for x-ray light for absolutely no foreseeable reason. He plans to use it to cover the glass windows on his car. The coating is to be made from a material with index of refraction 1.85. The specific frequency he wishes to not reflect is 3.0×10^{16} Hz. What is the minimum thickness of material that should be used? Make sure to show your work.



phase shift relative to each other $\Rightarrow$ destructive interference uses model: $m\lambda_{film}$ = PLD

PLD between rays is twice t

$\Rightarrow m\lambda_{film} = 2t$

$m=0 \Rightarrow$ no film

min thickness $\Rightarrow m=1$

$1\lambda_{film} = 2t$

$\Rightarrow t = \frac{5.41\,nm}{2}$

$\Rightarrow \boxed{t = 2.7\,nm}$

$v = f\lambda$

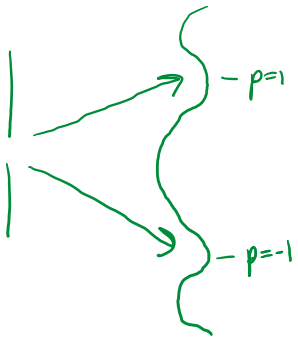
$\Rightarrow \lambda_{vac} = \frac{c}{f} = 10^{-8} = 10\,nm$

$v = \frac{c}{n} \Rightarrow \lambda_{film} = \frac{10\,nm}{1.85} = 5.41\,nm$

$\frac{\lambda}{a} = 0.21 \Rightarrow$ right on edge of small θ approx

7. **(8 points)** Two slits of width 3 μm are separated by 20 μm and illuminated by 635 nm wavelength light, creating both a single slit and a double slit diffraction pattern on the screen some distance away. How many double slit diffraction pattern maxima appear within the central bright spot of the single slit pattern? (again, make sure to show your work)

Single slit pattern $\Rightarrow$ $p\lambda = a\sin\theta$



$\Rightarrow$ for $p=1$, $\theta = 12.2°$

$\Rightarrow$ edge of central bright spot is $p = \pm 1 \Rightarrow \pm 12.2°$

double slit pattern $\Rightarrow$ $m\lambda = d\sin\theta$

how many fringes inside bright spot of

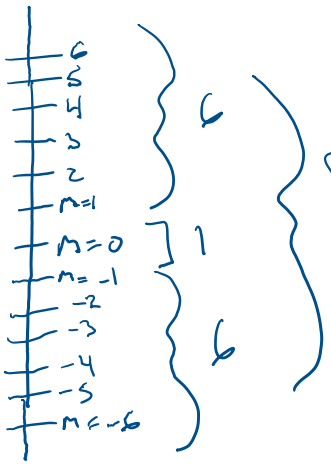
$\Rightarrow$ how many m values give $\theta < 12.2°$

$m\lambda = d\sin(12.2°)$

$\Rightarrow m = 6.67 \Rightarrow$ $m=6$ is inside bright spot

$m=7$ is outside bright spot

$\Rightarrow$



13 fringes