Name:___Solutions_________________ ID: ____________________

# Physics 203

## Midterm 1

4/22/2026

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

For questions 1 through 4 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **8** correct answers in this section and only the first **8** filled in answers will be graded. There is no partial credit.

## Question 1

Which of the following statements are true.

- ☑ (a) **Single slit** diffraction is more focused on dark spots
- ☐ (b) **Double slit** diffraction is more focused on dark spots
- ☐ (c) For **single slit** interference, the first dark fringe is **m = 0**
- ☑ (d) For **single slit** interference, the first dark fringe is **p = 1**
- ☐ (e) The interference pattern for **single and double slits** looks the same
- ☐ (f) The **single slit** has a dark spot in the middle, and the **double slit** has a bright spot in the middle

## Question 2

In a particular double-slit experiment, you note that the small-angle approximation is a good approximation. If the wavelength were increased by a factor of 3 in this experiment, what would happen to $\mathbf{y_2}$?

- ☐ (a) It would **decrease** by a factor of **9**
- ☐ (b) It would **decrease** by a factor of **3**
- ☐ (c) It would **decrease** by a factor of **3/2**
- ☐ (d) It would remain **unchanged**
- ☐ (e) It would **increase** by a factor of **2/3**
- ☑ (f) It would **increase** by a factor of **3**
- ☐ (g) It would **increase** by a factor of **9**

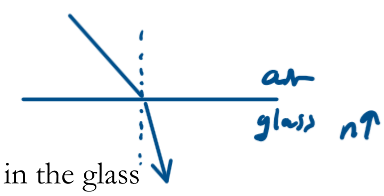
$m\lambda = d\theta$

$\underbrace{m\lambda}_{\downarrow \times \frac{1}{3}} = d\frac{y_m}{L} \;]\downarrow \times \frac{1}{3}$

## Question 3

When white light goes from air into a piece of glass, which of the following statements are true?

- ☐ (a) The light **speeds up** in the glass
- ☑ (b) The light **slows down** in the glass
- ☑ (c) The **wavelength** of the light **decreases** in the glass
- ☐ (d) The **wavelength** of the light **increases** in the glass
- ☐ (e) The frequency of the light **decreases** in the glass
- ☑ (f) The **index of refraction** is different for each frequency of light in the glass
- ☐ (g) The **angle the light refracts** is the same for all frequencies of light in the glass




## Question 4

You're brushing your teeth in front of a flat mirror. Which of the following statements are true?

- ☐ (a) The image you see of yourself is **evil**
- ☐ (b) The image you see of yourself is **real**
- ☑ (c) The image you see of yourself is **virtual**
- ☐ (d) The distance from you to the mirror is **greater than** the image distance to the mirror
- ☐ (e) The distance from you to the mirror is **less than** the image distance to the mirror
- ☑ (f) The distance from you to the mirror is **equal to** the image distance to the mirror
- ☐ (g) The mirror is not a real thing, and you are staring into the **underworld**

## Question 5

(10 points) A physicist lawyer is trying to prove the hair found at the crime scene is not from their client, or even from a human. Human hair has a width of between **50** to **150 µm**. You can measure hair width by treating it like a single slit where the width of the hair is the width of the slit. They shine a red laser of wavelength **680 nm** on a single strand of hair and see a single slit interference pattern on the wall. When the wall is **60 cm** away from the hair they measure the second dark fringe to be **47.2 cm** from the central maximum.

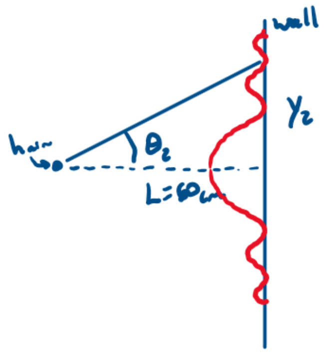
(a) Draw the physical representation shown in class for this situation.

(b) Can the lawyer use the small angle approximation? Justify your answer with equations, words, and a reference to the physical representation.

(c) What is the width of the hair found at the crime scene?

(d) Use known quantity sensemaking to determine if this hair could be from their client.

a)




b)


$\theta = \tan^{-1}\left(\frac{47.2}{60}\right) = 38.2°$

$\Rightarrow$ SAA is <u>not</u> good!

to be good $y \ll L$ must be true, but here, $y \sim L$

c) $p\lambda = a \sin\theta_p$, $\tan\theta_p = \frac{y_p}{L}$, $p = 2$

$\Rightarrow \theta_2 = \tan^{-1}\left(\frac{47.2}{60}\right) = 38.2°$

$\Rightarrow 2\lambda = a \sin(38.2°)$

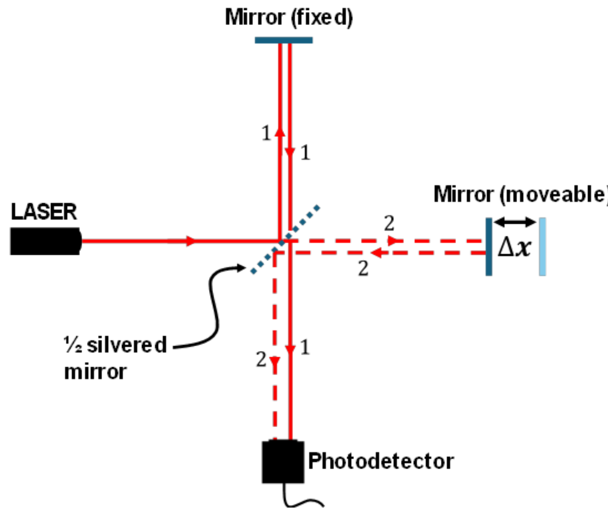
$\Rightarrow a = \frac{2(680\,nm)}{\sin(38.2°)} = 2.20\,\mu m$

d) this is much smaller than a human hair ($2.2\,\mu m < 50\,\mu m$)

$\Rightarrow$ cannot be from the client

## Question 6

(5 points) A Michelson Interferometer is a device designed to create interference between two waves. A laser produces light, of $\lambda = 700\ nm$, which is incident upon a 1/2 silvered mirror. This special mirror splits the beam in half, reflecting half of the light and transmitting the other half. This produces wave number 1 (solid line) and wave number 2 (dashed line) in the diagram. Initially, each wave travels the same distance, reflects off a mirror, then comes back to the 1/2 silvered mirror, where they are recombined and directed towards the photodetector.

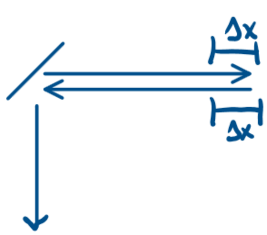



(a) Would you expect the photodetector to measure constructive or destructive interference with this setup? Explain using words, math, and references to the figure.

(b) If you move one of the mirrors, you go between constructive and destructive interference and can use the distance **Δx** to find the wavelength of the laser. How far would you need to move the mirror to go from destructive, to constructive, and back to destructive interference? Explain using words, math, and references to the figure.

a) constructive, waves 1 & 2 travel equal distances & started in phase ⇒ still in phase ⇒ constructive

b)




Δx gets traveled twice by wave 2

⇒ for $(0+\frac{1}{2})\lambda \rightarrow (1)\lambda \rightarrow (1+\frac{1}{2})\lambda$
destructive → constructive → destructive

⇒ PLD changes by $1\lambda$

⇒ Δx only needs to be $\frac{1}{2}\lambda$

⇒ **Δx = 350 nm**

## Question 7

(12 points) You place an object **33 cm** from a lens and notice the image it creates is real and on the opposite side of the lens, **16.5 cm** from the lens.

(a) Is the lens a converging or diverging lens? Explain how you determined this.

(b) Use the math representation to find the focal length of the lens.

(c) Use the math representation to find the magnification of the image.

(d) Use self-consistency sensemaking to check your answer to part (b). Do this by assuming the focal length is what you found in part (b) and draw a properly scaled ray tracing diagram as shown in class for this situation to show the location of the image. How well does your image location in part (d) align with the value given in the problem statement when you use your calculated focal length from part (b)?

(e) Is the image upright or inverted? Explain.

a) converging, image is real & on opposite side of lens

diverging lenses cannot make such images (w/ single lens sys.)

b) $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} = \frac{1}{33cm} + \frac{1}{16.5cm}$

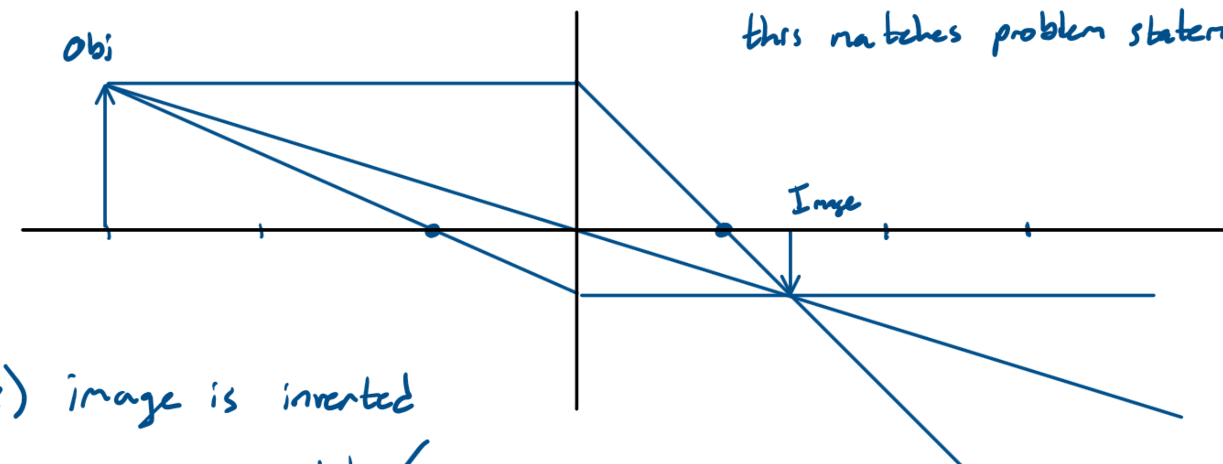
$\frac{1}{f} = \frac{3}{33cm} \Rightarrow \boxed{f = 11\ cm}$

c) $m = -\frac{d_i}{d_o} = -\frac{16.5\ \text{cm}}{33\ \text{cm}}$

$\boxed{m = -\frac{1}{2}}$

d) the image is located about ½ as far from lens as $d_o$ & on opposite side $\Rightarrow$ +16.5cm

this matches problem statement!




e) image is inverted

$m < 0 \Rightarrow$ match ✓