Name:_____ ID:_____

# Physics 203

## Midterm Exam 1

4/20/2022

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, 1 page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

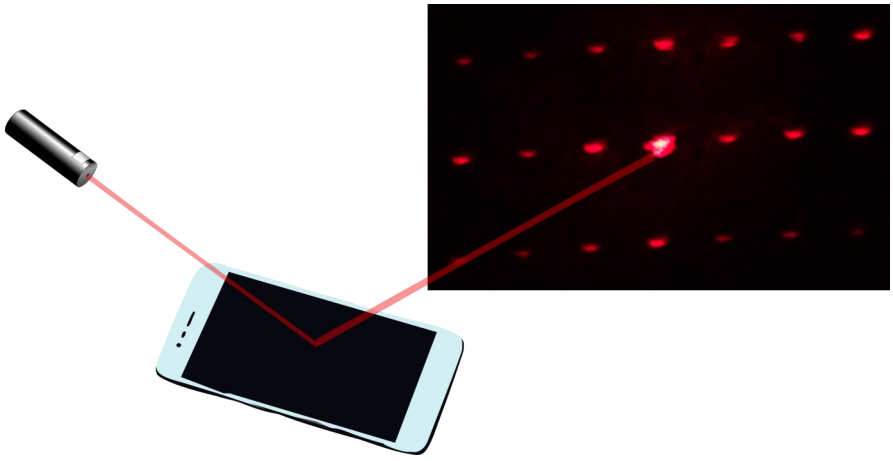
For questions 1 through 3 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **6** correct answers in this section and only the first **6** filled in answers will be graded. There is no partial credit.

1. For which of the following scenarios would we choose the mathematical model for the Path Length Difference, PLD = (m+1/2)λ?

   □ (a) Thin film interference with light of a specific wavelength incident from air onto an anti-reflection coating that causes destructive interference. The film's index of refraction is n = 1.5, and it is covering a metal surface of n = 12.
   □ (b) A double slit experiment, for which you are looking at the 3rd bright fringe.
   □ (c) Two speakers playing a loud constant tone. The sound is in phase when it leaves the speakers, but each speaker is a different distance from you. You hear a very loud tone.
   □ (d) Two speakers playing a loud constant tone. The sound is 180 degrees out of phase when it leaves the speakers, but each speaker is a different distance from you. You hear a very loud tone.

2. A red laser pointer was used to illuminate the surface of a cell phone screen. The LASER light was reflected off the cell phone screen and the resulting diffraction pattern was projected onto a wall . The image shows the picture of the light on the wall. Which of the following statements are true?

   □ (a) The underlying structure of the cell phone screen that reflects red light is arranged in a double helix pattern.
   □ (b) The underlying structure of the cell phone screen that reflects red light is arranged in a rectangular pattern.
   □ (c) The underlying structure of the cell phone screen that reflects red light is arranged in a circular pattern.
   □ (d) The underlying structure of the cell phone screen that reflects red light is arranged in a hexagonal pattern.



3. For which of the following situations can the small angle approximation be used?

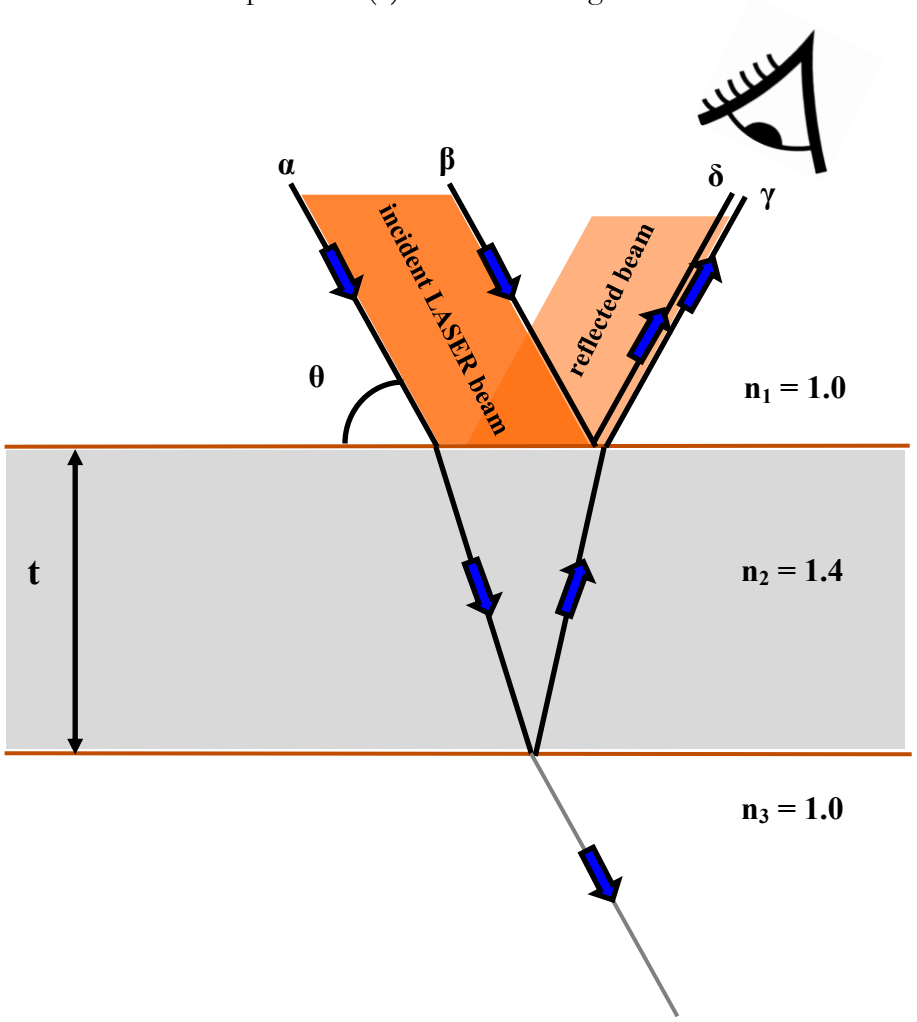
   □ (a) Single slit experiment where λ = 400 nm and the slit width is 33.0 μm.
   □ (b) Double slit experiment where λ = 650 nm and d = 1.40 μm.
   □ (c) Diffraction grating experiment where λ = 400 nm and there 14,000 lines per cm.
   □ (d) Reflection grating experiment where λ = 650 nm and there 1000 lines per cm.
   □ (e) A double slit experiment where $y_1$ = 2.2 cm and L is equal to 68 cm.

4. (8 points) Consider the thin film interference that occurs when a LASER beam is incident on a film ($\mathbf{n_2 = 1.4}$) of thickness $\mathbf{t = 55\ \mu m}$, that is suspended in air.

   (a) For this situation, which of the following conditions for the path length difference must be met for constructive interference of the reflected light, when viewed from above? Explain.

   (i) PLD = $m\lambda_2$, (ii) PLD = $(m+0.5)\lambda_2$

   (b) We have studied thin film interference for situations where the incident light is normal to the surface of the film. Interference can also occur when the light comes in at an angle. Assume all of rays ($\alpha$ and $\beta$ for example) in the laser beam are in phase when they hit the top surface of the film. What is the path length difference for the light that travels through the film, reflects off the bottom surface ($\gamma$), and then recombines with the rays reflected off the top surface ($\delta$)? Let $\boldsymbol{\theta}$ in the figure be equal to 65°.



5. (8 points) A single vertical slit of width 79 μm is 90 cm from a screen. A LASER of wavelength 626 nm is shone through the slit, casting an interference pattern horizontally across the screen. The screen is only 4.3 cm wide.

   (a) How many **bright fringes** appear on the screen?

   (b) Which one of the following quantities, when increased, will increase the number of bright fringes seen on the screen?

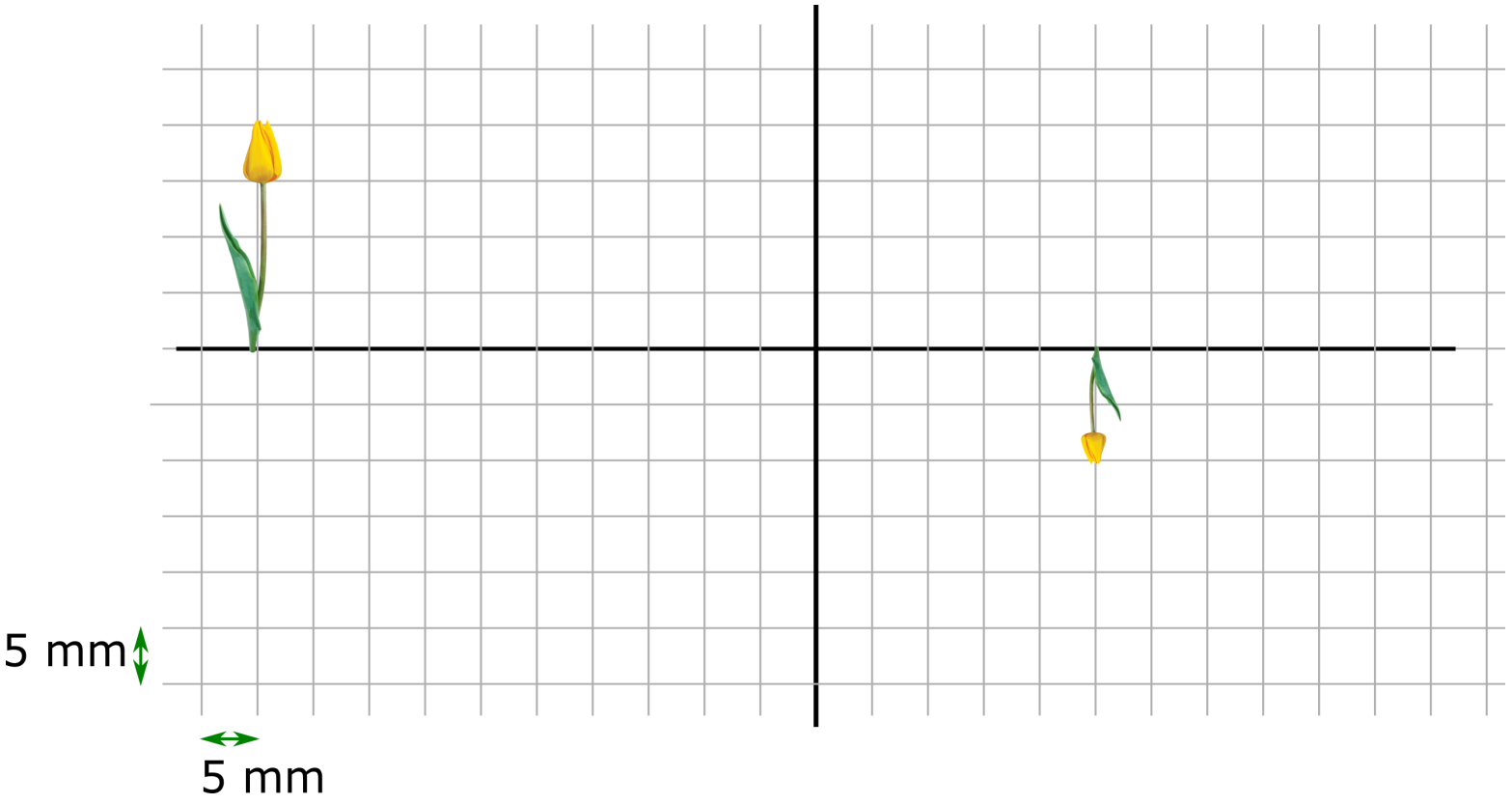
   (i) LASER wavelength
   (ii) slit width
   (iii) distance from slit to screen
   (iv) width of the central bright fringe

   Explain why the one you chose will increase the number of bright fringes, using words, symbols, diagrams, etc.

6. (9 points) Congratulations, you just won a contract to design and build a disposable camera! The specifications for your design are:

- You must use only one thin lens in your camera.
- A 20-mm-tall flower is placed 50.0 mm away from the thin lens and must produce a real image on film that is 25.0 mm away from the lens.

(a) What type of lens should you use to project an image onto the film? Converging or diverging? Explain.
(b) Use a sketch on the provided diagram to estimate the focal length of the camera lens. Each square is 5 mm by 5 mm. Your sketch should include one of the interesting rays discussed in class, and should also be drawn to scale. Clearly label your focal point on the sketch, and use that to estimate the focal length of the lens.
(c) Use the provided diagram to estimate the magnification of the image. Explain.
(d) Use the thin lens equation to calculate the focal length of the thin lens you will use in the camera.
(e) Use sense-making to compare your answer from the sketch in part (b) to your calculation in part (d).



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