Name:_____ ID:_____

# Physics 203

## Final Exam

6/12/2023

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 110 minutes to complete this exam.

**If you have any questions, especially about the definition of a word or phrase given in a question, please raise your hand and ask! We are happy to clarify!**

## Constants

$m_{proton} = 1.67 \times 10^{-27}$ kg

$m_{electron} = 9.11 \times 10^{-31}$ kg

$e = 1.60 \times 10^{-19}$ C

$k = 8.99 \times 10^{9}$ N m$^2$/C$^2$

$\mu_0 = 12.566 \times 10^{-7}$ N/A$^2$

$V_{sound\ in\ air} = 343$ m/s

$c = 3 \times 10^{8}$ m/s

$g = 9.81$ m/s$^2$

For questions 1 through 8 **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 **17** correct answers in this section and only the first **17** filled in answers will be graded. There is no partial credit.

1. A green laser (wavelength = 500 nanometers) shines through a thin film ($n_{film} = 1.2$) on one side of a piece of glass ($n_{glass} = 1.5$). Assume there is nothing but air ($n_{air} = 1$) between the laser source and the film. Which of the following statements about this situation are true?

   □ (a) The relative phase shift between the two reflected waves caused by reflection is pi.

   □ (b) The relative phase shift between the two reflected waves caused by reflection is 0.

   □ (c) The wavelength of the green light in the film is 600 nm.

   □ (d) The wavelength of the green light in the film is 500 nm.

   □ (e) The wavelength of the green light in the film is 417 nm.

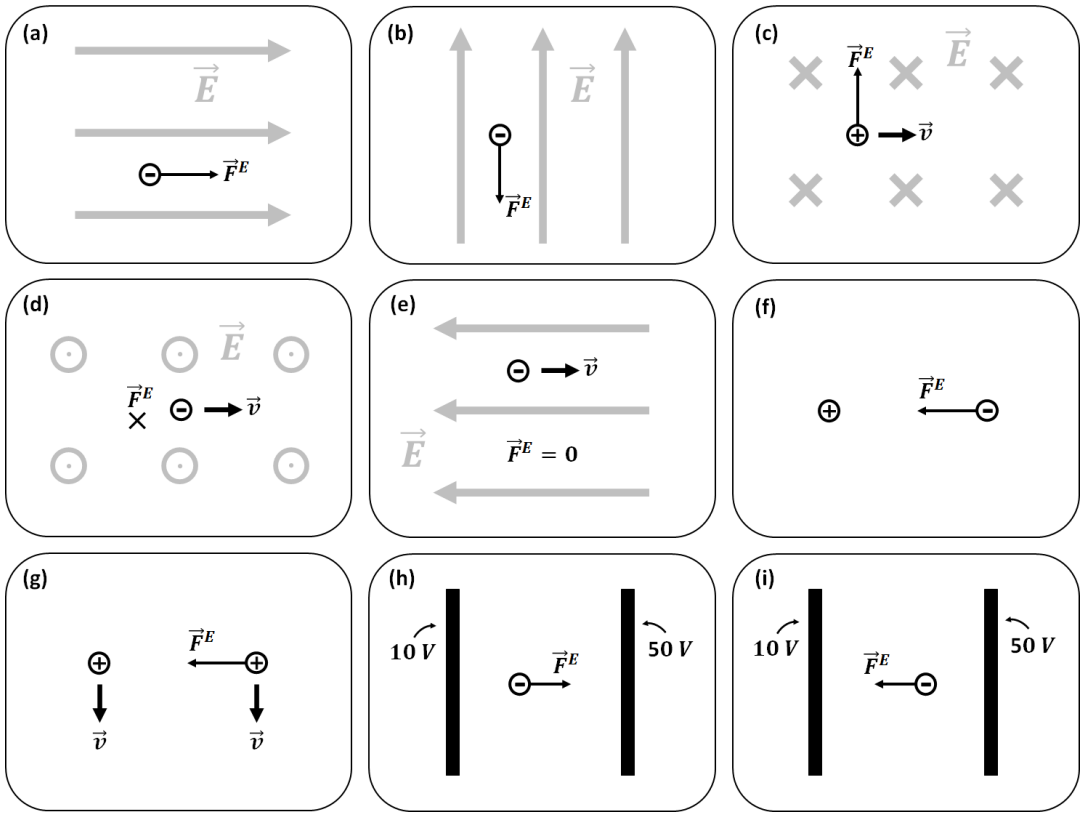
   □ (f) The wavelength of the green light in the film is 333 nm.

   □ (g) For destructive interference, we should choose the mathematical model: $m\lambda_{film} = 2t$

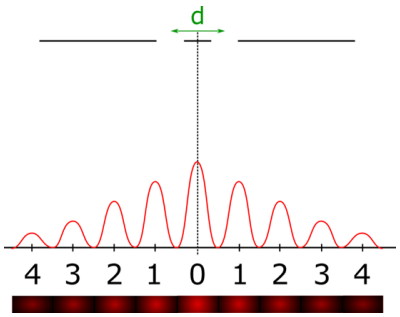
   □ (h) For destructive interference, we should choose the mathematical model: $\left(m + \frac{1}{2}\right)\lambda_{film} = 2t$

2. For which of the following situations is the electric force depicted in the correct direction?

   □ (a)
   □ (b)
   □ (c)
   □ (d)
   □ (e)
   □ (f)
   □ (g)
   □ (h)
   □ (i)



3. A red laser (wavelength 650 nm) shines through a double slit mask apparatus and produces the pattern seen below. Which of the following changes would cause the bright spots to become more closely spaced?



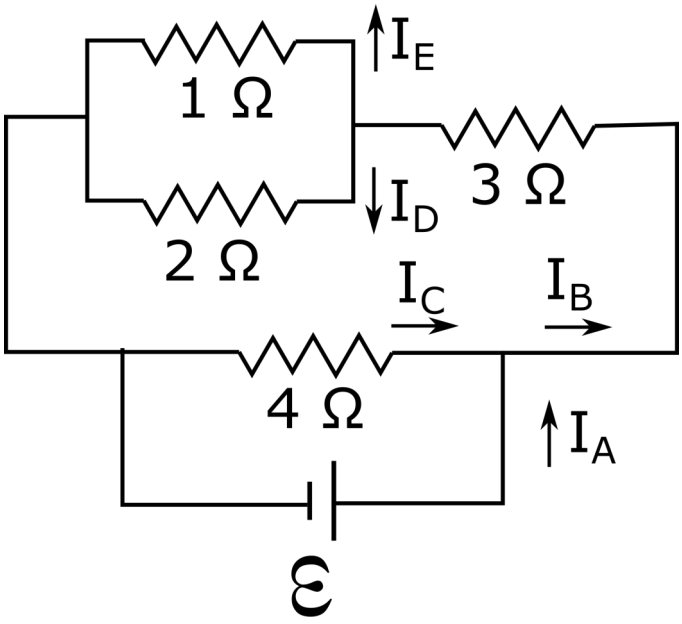

□ (a) Using a green laser with a wavelength of 500 nanometers.

□ (b) Moving the viewing screen farther from the 2-slit mask.

□ (c) Using a different mask with a larger slit-separation.

□ (d) Adding a third identical slit in between the existing slits, evenly spaced.

Questions 4, 5, and 6 each ask questions about the circuit pictured below.




4. How many unique junctions are in the circuit?

□ (a) 0 ; no junctions.

□ (b) 1

□ (c) 2

□ (d) 3

□ (e) 4

5. What is the equivalent resistance of the circuit?

□ (a) 2/3 Ω

□ (b) 3/2 Ω

□ (c) 3/11 Ω

□ (d) 11/3 Ω

□ (e) 44/23 Ω

□ (f) 23/44 Ω

6. Which of the following Kirchhoff loop equations is/are a valid equation for the circuit?

□ (a) $\mathcal{E} + 4\ I_C = 0$

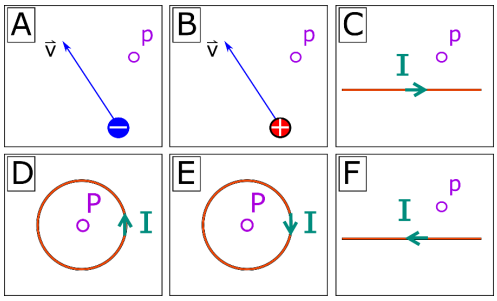
□ (b) $\mathcal{E} - 3\ I_B - 2\ I_D - I_E = 0$

□ (c) $\mathcal{E} - 3\ I_B - 2\ I_D = 0$

□ (d) $\mathcal{E} + 3\ I_B = 0$

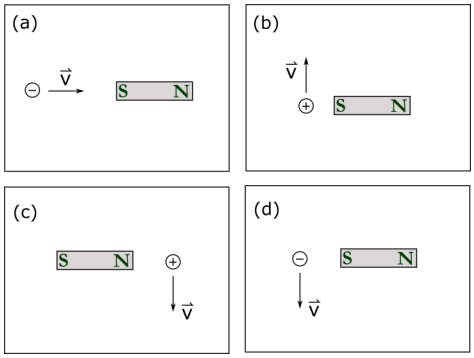
7. Which of the following scenarios create a magnetic field that points out of the page at point P?

□ (a) A
□ (b) B
□ (c) C
□ (d) D
□ (e) E
□ (e) F




8. For which of the following situations is the magnetic force on the moving charge directed out of the page?

□ (a)
□ (b)
□ (c)
□ (d)

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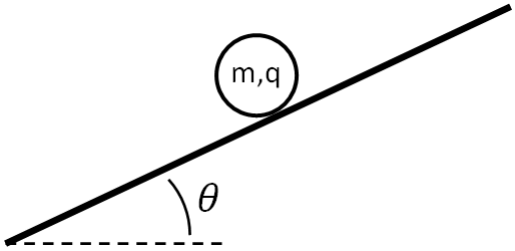
Free Response Questions:

9. (6 pts) A green laser (wavelength 500 nanometers) passes through a diffraction grating with 1200 lines per centimeter. This produces an interference pattern on a screen 135 centimeters away.

(a) Assuming the screen is sufficiently large, how many bright spots could be captured on the screen?

(b) Determine the angle at which the 1st order bright fringe is located.

10. (7 pts) A sphere of charge **q = –0.03 C** and mass **m = 0.04 kg** is resting in static equilibrium on a frictionless incline which makes an angle **θ** with the horizontal as pictured. A uniform electric field of **25 N/C** is also present in the region. Assume a standard coordinate system for this question.

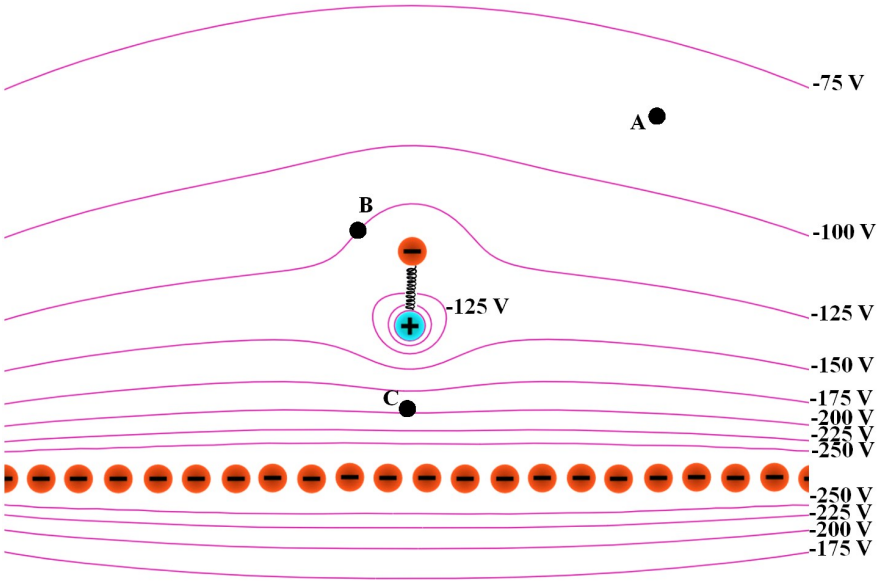



(a) If the y and z components of the electric field are zero, is the x-component of the electric field positive or negative? Explain.

(b) What is the value of **θ?**

11. (11 pts) The figure shows equipotential lines for a dipole near a flat negatively charged surface. There are three points of interest labeled A, B, and C.

(a) Rank the magnitude of the electric field at the points A, B, and C. Explain the reasoning behind your ranking.




(b) Sketch a vector representing the electric field at each point, A, B, and C. The length of the vector should represent the magnitude of the electric field at that point. Explain the reasoning behind how you oriented the vectors.

(c) If an electron is released at point C, which direction will it begin to move?

(d) If the dipole is released from rest at it's current location, which direction, if any, will it begin to move? Explain your reasoning.

12. (9 pts) General Disarray has hidden a stolen treasure below a 100-m-deep (d) lake. To open the room where the treasure lies you must shine his giant laser on the light sensor in the bottom of the lake. The only problem is he designed it so the minimum incident angle is 40°, which still misses the light sensor. He thought this would keep his treasure safe - he didn't count on your superior knowledge of physics.

(a) At the current state of the system (incident angle = 40°), find the horizontal distance x, between where the light enters the water and where it shines on the bottom.
(b) Would you want to increase or decrease the index of refraction of the water to get closer to the sensor? Explain.
(c) If the horizontal distance x needs to be decreased by 30 cm to hit the sensor, what new index of refraction would achieve this? After the exam you can look up what concentration of salt in the water would achieve this index and decide whether the fish will survive that much salt!