Name _____   **Seat Number** _____
   last   *first*   *initial*

Signature _____   **Student Number** _____

- **Print and sign your name, and write your Student ID Number and seat number legibly in the spaces above.**

- **Write your name and Student ID Number on the bubble sheet and fill in the corresponding "bubbles" on the answer sheet.**

Do not open the exam before told.

Completed exams will not be accepted more than 1 hour, 55 minutes after the exam begins.

- **When the exam starts, it is very important that you print your name at the top of every exam page**. This should be the **first** thing you do when you are told to open your exam.

Instructions

- This is a closed book examination. You may have one sheet of paper on which you have written information that you might find useful. You may use a calculator.

- If you need more space than is available to answer a question, use the back side **of the same page** to complete your answer. Clearly indicate to the grader that you have used the back side. Do not use scratch paper.

- Show your work in enough detail that the grader will be able to understand your reasoning and your method of solution. Circle your answers, and, if appropriate, state the units. For numerical answers, 2 significant figures (*e.g.,* 1.2 seconds, 6.1×10^2 m) will be sufficient, unless stated otherwise.

- If you are confused about a question, raise your hand and ask for an explanation. If you cannot do one part of a problem, move on to the next.

Constants

This is not meant to be a complete list…

$h = 6.63 \times 10^{-34}$ J-s

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

$e = 1.6 \times 10^{-19}$ C

$c = 3.0 \times 10^8$ m/s

$R = 1.097 \times 10^7$ m^{-1}

$a_0 = 5.292 \times 10^{-11}$ m

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

Name _____   Total _____

(Last, First)   Phys 123A

I. [12 points] Two linearly polarizing sheets are arranged one after the other as shown in
    the figure below. The polarization axis of the first polarizer (I) is parallel to the y axis.
    The polarization axis of the second (II) sheet is 90 degrees with respect to the first.
    Each sheet is 2 meters in diameter, and they are separated by a distance of 2L.
    Unpolarized light of 50W is shining on the first sheet.
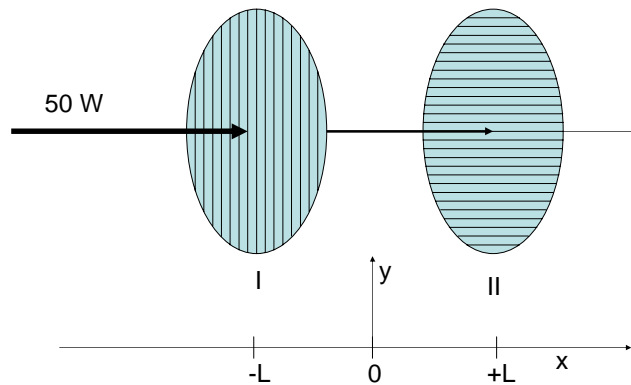
1. [3 points] What is the power of light shining on the second sheet?
    A. 0 W
    B. 5 W
    C. 25 W
    D. 35 W
    E. 50 W

2. [3 points] What power does the second sheet absorb?
    A. 0 W
    B. 5 W
    C. 25 W
    D. 35 W
    E. 50 W

For problems 3 and 4 we now place a third polarizer, of the same size, between the
first two (at *x*=0). Its polarization axis is at 10 degrees from the first polarizer.

3. [3 points] How much power does this new polarizer absorb?
    A. 0.0 W
    B. 0.38 W
    C. 0.75 W
    D. 2.8 W
    E. 24.2 W
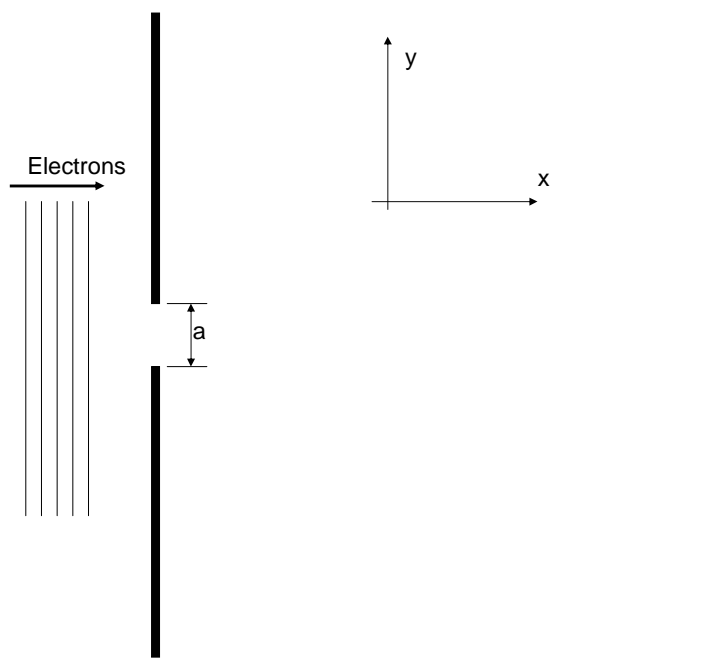
4. [3 points] What is the power incident on a 1 meter diameter disk placed after polarizer II now?
    A. 0.0 W
    B. 0.0057 W
    C. 0.0023 W
    D. 0.75 W
    E. 24.2 W

II. [13 points] Consider the electron single slit diffraction setup shown below. The slit width, a, is 1000 nm.

5. [2 points] If we decrease the slit width, a, by a factor of two, the uncertainty principle says:
   A. Momentum of the electron in the x direction better
   B. Momentum of the electron in the y direction better
   C. Momentum of the electron in the x direction worse
   D. Momentum of the electron in the y direction worse
   E. None of the above

6. [3 points] If we lived in a universe where Plank's constant, h, was 0.6 J-s instead of its correct value, would the width of a maxima
   A. Get Bigger
   B. Get Smaller, or
   C. Stay the Same Size

Next, consider an electron with a kinetic energy of 10 eV, moving in the x direction.

7. [4 points] If we know the x-position of the electron to 10 nm, how well will we know its KE?
   A. ± 0 eV
   B. ± 0.12 eV
   C. ± 4.20 eV
   D. ± 5.61 eV
   E. ± 6.25 eV

8. [4 points] You are catching fly balls for Ichiro Suzuki. He has popped one very high and you are standing directly under it as it falls towards you. You can estimate the 0.5kg base-ball's side-to-side movement to an accuracy of 10 cm/sec. Your eye tells you it is falling straight down on top of you. If Plank's constant was 0.6 J-s, how big a base ball mitt would you need to catch this fly ball? Round to nearest order of magnitude.
    A. 1 cm
    B. 10 cm
    C. 1 m
    D. 10 m
    E. 100 m

9. [0 points] Who had the best season finale?
    A. Buffy
    B. The Sopranos
    C. The West Wing
    D. Voyager
    E. Other

III. [20 points]

A tuning fork is sounded in the middle of an empty room.

10. [4 points] Which of the following statements best describes the motion of air particles as the sound wave passes by those particles:
    A. Oscillate perpendicular to the direction of propagation
    B. Oscillate parallel to the direction of propagation.
    C. Move away from the source.
    D. Both A and B.
    E. None of the above.

11. [4 points] Which of the following is true? Compared to the situation in problem 10 if the tuning fork were made to vibrate at twice the frequency (but emitted the same intensity of sound):
    A. The air particles' maximum displacement from equilibrium will increase.
    B. The maximum displacement will not change.
    C. The air particles will be less displaced.
    D. None of the above.

A first tuning fork is placed at position T as shown in the diagram below. It emits sound at a frequency F. If a second identical tuning fork is placed at position II, then total destructive interference takes place at position O, where an observer is located. Assume that intensity of due to a tuning fork does not fall off with distance.
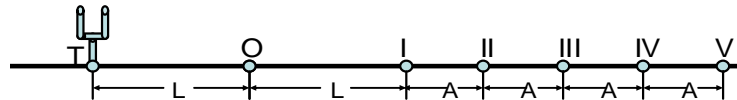
12. [4 points] At which of the following other positions can you also place the second tuning fork to achieve total destructive interference for the observer at point O?
    A. I
    B. III
    C. IV
    D. V
    E. Both III and V

You have three tuning forks, A, B, and C. Fork B has a frequency of 440 Hz. When A and B are sounded together, a beat frequency of 3 Hz is heard. When B and C are sounded together the beat frequency is 4 Hz.

13. [4 points] What is the smallest possible frequency that A could have?
   A. 434 Hz
   B. 437 Hz
   C. 440 Hz
   D. 443 Hz
   E. 446 Hz

14. [4 points] What is the smallest possible beat frequency when A and C are sounded together?
   A. 1 Hz
   B. 2 Hz
   C. 3 Hz
   D. 5 Hz
   E. 7 Hz

V. (30 points, total) *Fun with optical instruments!!!*
Multiple choice. For each question below, choose *one* answer and indicate the answer on your bubble sheet.
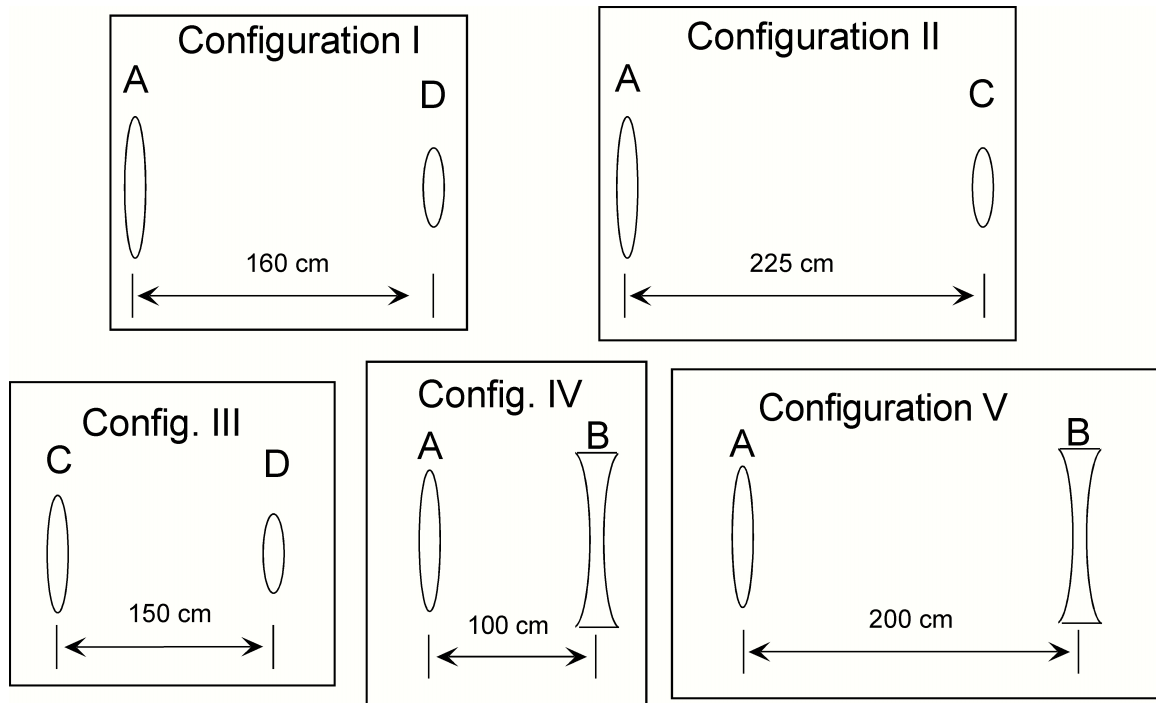
Consider the configurations of lenses sketched above. In each case, lenses A, B, C, and D have focal lengths of $f_A = 150$ cm, $f_B = -50$ cm, $f_C = 75$ cm, and $f_D = 10$ cm, respectively.

25. (3 pts.) Which of the lens configurations would best be described as a Galilean telescope?

    A. both I and II   B. only III   C. only IV
          D. only V   E. both IV and V

26. (3 pts.) Which of the lens configurations would be best described as a compound microscope?

    A. both I and II   B. only III   C. only IV
          D. only V   E. both IV and V

27. (3 pts.) Which of the lens configurations I, II, or III would give the largest angular magnification?

        A. I   B. II   C. III

Name (Last, First) _____

V. (Continued)

For each of the questions below, indicate on your bubble sheet whether the statement is true or false.

28. (3 pts.) The only difference between a Keplerian telescope and a compound microscope is that the compound microscope must use short focal length lenses for both the objective and the eyepiece.
    A. true   B. false

29. (3 pts.) For all telescopes that you studied in the lab, the final image which you viewed was a real image at infinity.
    A. true   B. false

30. (3 pts.) The shorter the focal length of a simple (one lens) magnifier, the smaller the magnification.
    A. true   B. false

31. (3 pts.) For a simple (one lens) magnifier, the image that you see is virtual, erect, and at infinity.
    A. true   B. false

32. (3 pts.) The lateral magnification of an object by a compound microscope depends on the choice of a near point.
    A. true   B. false

33. (3 pts.) For the compound microscope that you studied in the lab, the image that you viewed was an virtual, inverted image at infinity.
   A. true   B. false

34. (3 pts.) For the compound microscope that you studied in the lab, the lateral magnification is independent of the properties of the eyepiece lens.
    A. true   B. false

VI. [20 points total] An electromagnetic plane wave propagates through free space. The electric field points along the y-axis; the magnetic field points along the z-axis. Two halves of a steel wire are connected to a light bulb. The wire is oriented in the y-z plane, making an angle α with the y-axis. As the wave propagates past the wire, *the bulb is observed to glow.*

Wire oriented in y–z plane
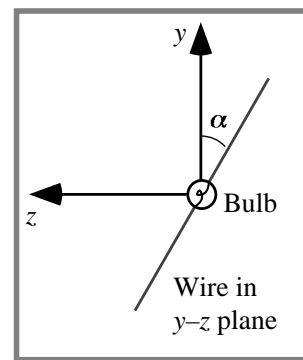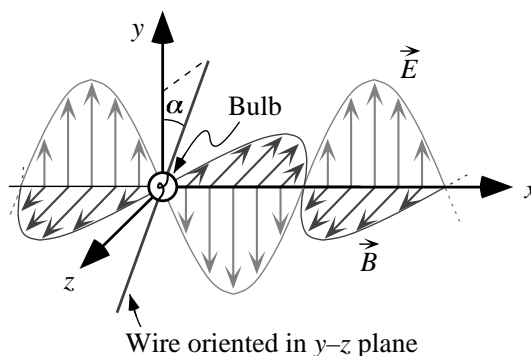
View along x-axis

35. [4 pts] Suppose the wire were oriented to make a larger angle with the y-axis (*i.e.,* α increases but is still less than 90°). Would the brightness of the bulb:
    (a) increase
    (b) decrease
    (c) stay the same
    (d) not enough information to determine

36. [4 pts] Suppose instead that the wire were shifted downward (in the –y direction) by a distance *d,* where *d* is the length of the wire. Would the brightness of the bulb:
    (a) increase
    (b) decrease
    (c) stay the same
    (d) not enough information to determine

37. [4 pts] Suppose instead that the wire were bent into a 'V' shape, shown at right (the wire is still oriented in the y-z plane). Would the brightness of the bulb:
    (a) increase
    (b) decrease
    (c) stay the same
    (d) not enough information to determine
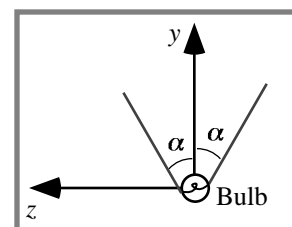

View along x-axis

The wire-and-bulb device described above is replaced with a loop-shaped antenna, shown at right.
Assume the loop is very small compared to the wavelength of the EM wave.
38. [4 pts] In order to use the loop-shaped antenna to detect the EM wave, would you orient the loop parallel to the
    (a) x-y plane
    (b) y-z plane
    (c) x-z plane
    (d) none of the above

Connections to circuit
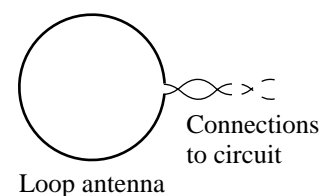
Loop antenna

Suppose the loop antenna is oriented such that a current is present in the circuit to which it is connected.
39. [4 pts] If the lower semi-circle of the loop antenna were replaced by a straight segment, as shown, how would the current in the circuit be affected? (*Hint*: do not neglect the resistance of the loop.)
    (a) the current will stay the same
    (b) the current will decrease by a factor less than two
    (c) the current will decrease by a factor of two
    (d) the current will increase
    (e) not enough information to determine

Connections to circuit

Loop antenna
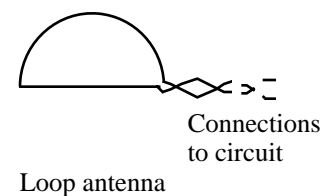
VII.[25 pts total] A beam of
   monoenergetic protons is
   incident on two narrow slits.
   The graph at right represents
   the intensity on a
   phosphorescent screen
   placed far from the slits.
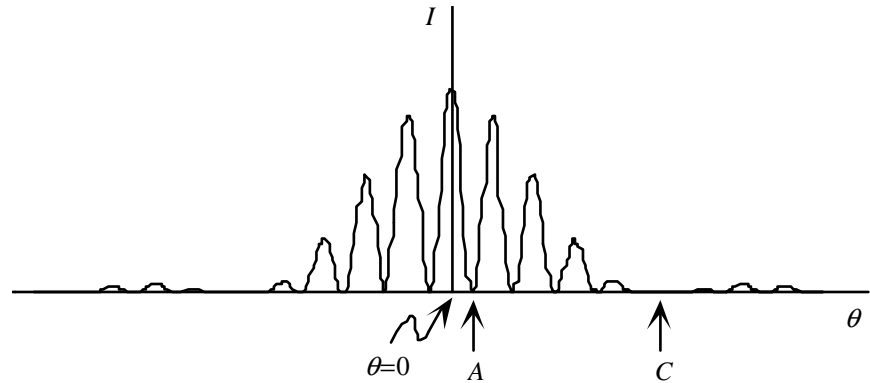
40. [10 pts] The width of
    each slit is decreased
    slightly (while the
    centers of the slits
    remain the same distance apart). Will the intensity at the following points *increase, decrease,* or
    remain the same? Explain.

    - point *A*

    - point *C*

    - the center of the pattern ($\theta = 0$)

41. [7 pts] Consider the original experiment (*i.e.,* before the slit width is changed). Suppose that,
    instead of protons, monoenergetic electrons of the same kinetic energy as the protons are incident
    on the slits. (The mass of an electron is less than that of a proton.)

    Would the intensity at point *A* on the screen *increase, decrease,* or *remain the same?* Explain.

42. [8 pts] Consider the original experiment. A sensor is now placed at the left slit. The sensor
    beeps when a proton passes through that slit. (In separate experiments, it is observed that the
    presence of the sensor at a slit does not change the pattern on the screen for a *single-slit*
    experiment.)

    Predict whether the intensity at each of the following points on the screen *increases, decreases,*
    or *remains the same.* Explain.

    - point *A*

    - point *C*