

# FINAL EXAMINATION

**PHYS-1200 PHYSICS II**

**DECEMBER 15, 2006**

NAME \_\_\_\_\_

Put a mark in the box next to the section of the course to which you are assigned.

	<b>SECTION NUMBER</b>	<b>EXAMINATION ROOM</b>	<b>INSTRUCTOR</b>	<b>DAY AND TIME THAT SECTION MEETS</b>
	1	DCC 308	SUSANNE HAUGER	MR 8:00 A.M.
	2	DCC 308	SUSANNE HAUGER	MR 10:00 A.M.
	3	DCC 308	TIMOTHY HAYES	MR 10:00 A.M.
	4	DCC 308	THOMAS SHANNON	MR 12:00 NOON.
	5	DCC 308	SCOTT DWYER	MR 12:00 NOON.
	6	DCC 308	TIMOTHY HAYES	MR 2:00 P.M.
	7	DCC 308	SCOTT DWYER	MR 2:00 P.M.
	8	DCC 308	TIMOTHY HAYES	MR 4:00 P.M.
	9	DCC 308	GYORGY KORNISS	TF 10:00 A.M.
	10	DCC 308	GYORGY KORNISS	TF 12:00 NOON
	11	DCC 308	ANGEL GARCIA	TF 12:00 NOON
	12	DCC 308	SHAWN-YU LIN	TF 2:00 P.M.

There are 12 different pages in this quiz, including the cover page. Check now to see that you have all of them.

There is a total of 200 points on this examination.

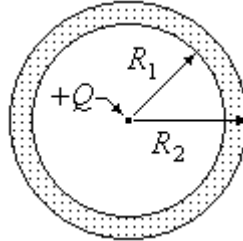
	<b>CREDIT</b>	<b>GRADE</b>
PART A	100 pts	
PART B	36 pts	
PART C-1	20 pts	
PART C-2	32 pts	
PART C-3	12 pts	
TOTAL	200 pts	

All work and answers must be given in the spaces provided on these pages.

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**PART A.** (100 pts) There are 20 questions worth 5 points each. In the space provided, to the left of the question number, write the letter corresponding to the best answer to the question.

- \_\_\_ 1. A positive charge  $+Q$  is placed at the center of a hollow conducting sphere of inner radius  $R_1$ , and outer radius  $R_2$ , as shown. The sphere was uncharged when  $+Q$  was placed at its center.

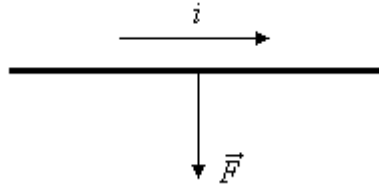


With the charge  $+Q$  at the center of the sphere, the charge on the inner surface of the sphere is:

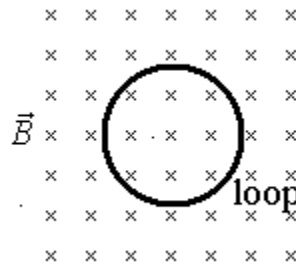
- A.  $+Q$       B.  $-Q$       C. 0      D.  $+Q\left(\frac{R_1}{R_2}\right)^2$       E.  $-Q\left(\frac{R_1}{R_2}\right)^2$
- \_\_\_ 2. Increasing the separation between the plates of a parallel plate capacitor that is connected to a battery which keeps the potential difference between the plates constant:
- A. increases the capacitance
  - B. increases the electric field between the plates
  - C. increases the charge on the capacitor
  - D. decreases the charge on the capacitor
  - E. does not change the charge on the capacitor
- \_\_\_ 3. Two pieces of wire made of the same material have the same lengths but different diameters. They are connected in series to a battery. The quantity that is the same for the two wires is:
- A. the potential difference between the ends of each wire
  - B. the current
  - C. the current density
  - D. the electric field
  - E. the electron drift velocity

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- \_\_\_ 4. The diagram shows a straight wire carrying current  $i$  in a uniform magnetic field. The direction of the current is indicated on the diagram, and the magnetic force on the wire is indicated by an arrow, but the magnetic field is not shown. Of the following possibilities, the direction of the magnetic field is:



- A. opposite the direction of the current  
B. opposite the direction of  $\vec{F}$   
C. in the direction of  $\vec{F}$   
D. into the page  
E. out of the page
- \_\_\_ 5. A circular loop of wire is perpendicular to a uniform magnetic field that is increasing in magnitude, and directed into the page as shown in the picture.



Consider the following factors:

- I. the strength of the magnetic field
- II. the rate of change of the magnetic field
- III. the radius of the loop

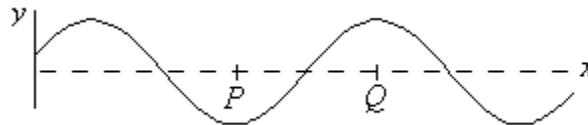
Which can affect the emf induced in the coil?

- A. I only      B. II only      C. I and II only      D. II and III only      E. I, II, III
- \_\_\_ 6. A particle oscillating in simple harmonic motion is:
- A. in equilibrium at the ends of its path because its velocity is zero there
  - B. in equilibrium at the center of its path because its acceleration is zero there
  - C. in equilibrium at the ends of its path because its acceleration is zero there
  - D. never in equilibrium because it is in motion
  - E. never in equilibrium because there is always a force
- \_\_\_ 7. In an oscillating  $LC$  circuit, the magnitude of the charge on the capacitor is a maximum when:
- A. the emf in the inductor is a maximum.
  - B. the current in the inductor is a maximum.
  - C. the emf in the inductor is zero.
  - D. the rate of change of current is zero.
  - E. none of the above

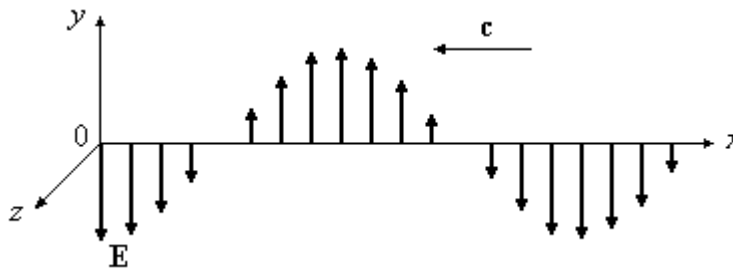
- \_\_\_ 8. Two of Maxwell's equations contain a line integral around a closed path. For them, the infinitesimal line segment  $d\vec{s}$  is always:
- A. tangent to the path
  - B. perpendicular to the path and pointing outward
  - C. perpendicular to the path and pointing inward
  - D. tangent to a field line
  - E. perpendicular to a field line

- \_\_\_ 9. Displacement current exists in the region between the plates of a parallel plate capacitor if:
- A. the capacitor leaks charge across the plates
  - B. the capacitor is being discharged
  - C. the capacitor is fully charged
  - D. the capacitor is fully discharged
  - E. none of the above

- \_\_\_ 10. The diagram below shows the displacement as a function of position for a section of string as a sinusoidal wave travels along the string. The interval  $PQ$  represents:



- A. wavelength/2
  - B. wavelength
  - C. period/2
  - D. period
  - E.  $2 \times$  amplitude
- \_\_\_ 11. The electric field for a plane electromagnetic wave traveling in the  $-x$  direction is shown. The  $+z$  direction points out of the page. The direction of the  $\vec{B}$  field at  $x = 0$ , where  $\vec{E}$  points in the  $-y$  direction, is:



- A.  $+y$
- B.  $-y$
- C.  $+z$
- D.  $-z$
- E. some other direction

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\_\_\_ 12. The dimensions of  $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$  are:

- A. J/m<sup>2</sup>      B. J/s      C. W/s      D. W/m<sup>2</sup>      E. J/m<sup>3</sup>

\_\_\_ 13. In a Young's double slit experiment, the separation between the interference maxima on the screen can be changed by the following actions:

- I. Increasing the distance between the slits.
- II. Decreasing the distance between the slits.
- III. Increasing the wavelength of the light used.
- IV. Decreasing the wavelength of the light used.
- V. Increasing the distance from the slits to the screen.
- VI. Decreasing the distance from the slits to the screen.

Those actions that will *decrease* the separation between the maxima are:

- A. I, III, and V      D. II, III, and V  
B. II, IV, and VI      E. I, IV, and V  
C. I, IV, and VI

\_\_\_ 14. The locations of the minima of the diffraction pattern from a single slit are given by the equation  $m\lambda = a \sin \theta$ . In this equation, the quantity  $m\lambda$  represents:

- A. the width of the slit  
B. the distance from the slit to the screen  
C. the path length difference between waves that come from the middle of the slit and one edge of the slit  
D. the path length difference between waves that come from the two opposite edges of the slit  
E. none of the above

\_\_\_ 15. Which of the following is evidence of the wave nature of matter?

- A. The photoelectric effect      D. Electron tunneling  
B. The Compton effect      E. The momentum of photons  
C. Young's double slit experiment

\_\_\_ 16. The positions of an electron and a proton are both measured with the same uncertainty  $\Delta x$ . According to the Heisenberg Uncertainty Principle, the uncertainty in the *momentum* of the proton,  $\Delta p_x$ , is:

- A. greater than that of the electron  
B. equal to that of the electron  
C. less than that of the electron  
D. opposite in sign to that of the electron  
E. equal to Planck's constant divided by  $2\pi$

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- \_\_\_17. If  $E_0$  and  $E_T$  are the average energies of the “free” electrons in a metal at 0 K and room temperature respectively, then the ratio  $E_T/E_0$  is approximately:  
A. 0            B. 1            C. 100            D.  $10^6$             E.  $10^{10}$
- \_\_\_18. When the temperature of a piece of copper wire is increased, its resistance:  
A. increases because the number of conduction electrons decreases  
B. decreases because the number of conduction electrons increases  
C. increases because the electrons collide with atoms at an increased rate  
D. decreases because the electrons collide with atoms at a decreased rate  
E. increases because the energy gap increases
- \_\_\_19. When the temperature of a pure semiconductor is increased, its resistance:  
A. increases because the number of conduction electrons decreases  
B. decreases because the number of conduction electrons increases  
C. increases because the electrons collide with atoms at an increased rate  
D. decreases because the electrons collide with atoms at a decreased rate  
E. increases because the energy gap increases
- \_\_\_20. The junction between a  $p$ -type semiconductor and an  $n$ -type semiconductor is called a  $p$ - $n$  junction. In an unbiased  $p$ - $n$  junction:  
A. the electric field is zero throughout the junction.  
B. the  $n$  side and the  $p$  side are at the same potential.  
C. the  $p$  side is at higher potential than the  $n$  side.  
D. the  $n$  side is at higher potential than the  $p$  side  
E. the depletion zone is a region that contains no matter.

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**PART B.** (36 pts) Write numerical answers in the spaces provided.

1. (8 pts) The circles in the figure below represent four long straight wires that are perpendicular to the page and carry currents. The currents in all four wires are equal in magnitude, and directed into the page.



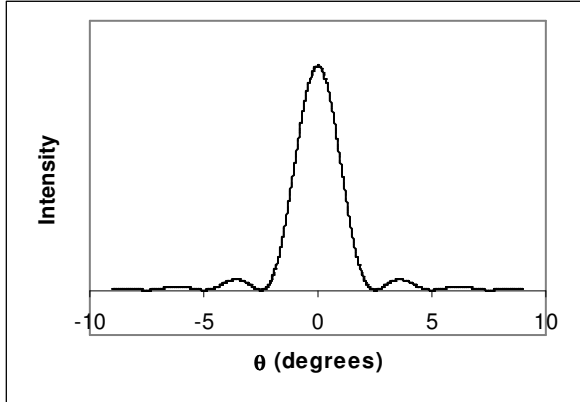
- a) (4 pts) Consider the wire labeled *P* in the sketch. What is the direction of the magnetic field produced by the other three wires at the location of the wire labeled *P*? (Circle the correct answer.)

$\uparrow$    
   $\downarrow$    
   $\rightarrow$    
   $\leftarrow$    
  SOME OTHER DIRECTION   
   $B = 0$  at *P*

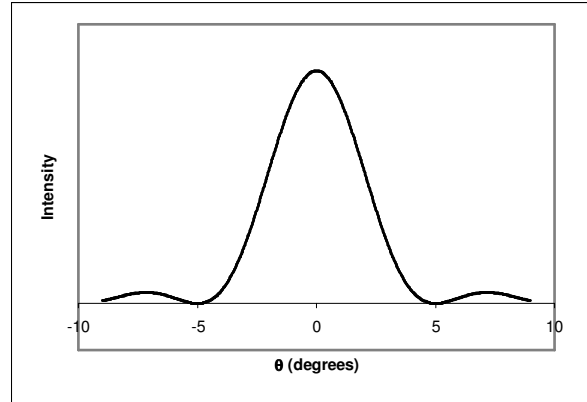
- b) (4 pts) What is the direction of the force on the wire labeled *P* due to the other three wires? (Circle the correct answer.)

$\uparrow$    
   $\downarrow$    
   $\rightarrow$    
   $\leftarrow$    
  SOME OTHER DIRECTION   
   $F = 0$

2. (8 pts) The graphs below show the diffraction patterns as a function of angle, produced by two beams of electrons that have passed through the same narrow slit at different times.



Beam A



Beam B

- a) (4%) For which of the two beams is the wavelength of the electrons greater? (Circle the correct answer.)

**Beam A**

**Beam B**

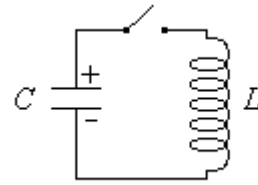
- b) (4%) For which of the two beams is the speed of the electrons greater? (Circle the correct answer.)

**Beam A**

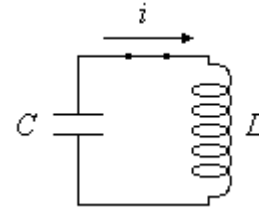
**Beam B**

NAME \_\_\_\_\_

3. (12 pts) The sketch shows a charged capacitor  $C$ , in series with an inductor  $L$ , and an open switch. When the switch is closed, the electromagnetic oscillations begin.



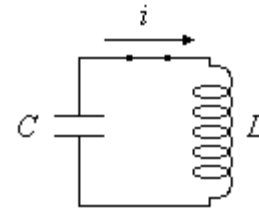
a) (4 pts) At some time after the switch is closed, the current is found to be flowing in the direction shown in the sketch at the right, and it is *increasing* in magnitude. The direction of the electric field between the plates of the capacitor is: (Circle the correct answer.)



$\uparrow$     
   $\downarrow$     
   $\rightarrow$     
   $\leftarrow$     
 SOME OTHER DIRECTION

$E = 0$

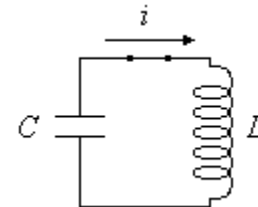
b) (4 pts) At some time after the switch is closed, the current is found to be flowing in the direction shown in the sketch at the right, and it is *increasing* in magnitude. The direction in which the displacement current is flowing between the plates of the capacitor is: (Circle the correct answer.)



$\uparrow$     
   $\downarrow$     
   $\rightarrow$     
   $\leftarrow$     
 SOME OTHER DIRECTION

$i_d = 0$

c) (4 pts) At some time after the switch is closed, the current is found to be flowing in the direction shown in the sketch at the right, and it is *increasing* in magnitude. The direction of the emf in the inductor is: (Circle the correct answer.)

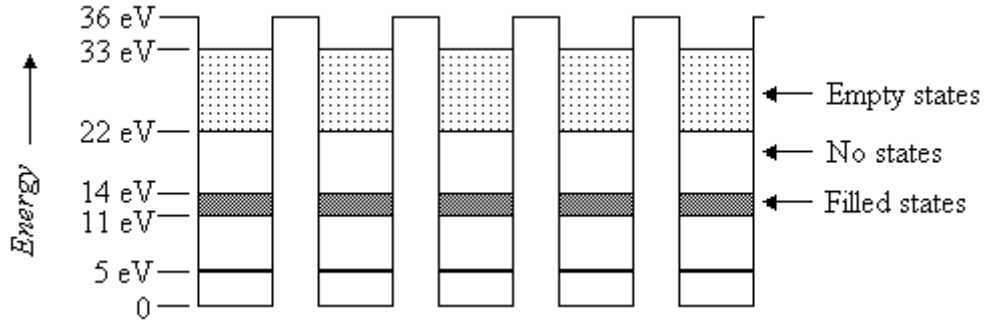


$\uparrow$     
   $\downarrow$     
   $\rightarrow$     
   $\leftarrow$     
 SOME OTHER DIRECTION

$\mathcal{E} = 0$

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4. (8 pts) The diagram below shows a portion of an array of finite potential energy wells that have been brought close together to form energy bands, and simulate a solid. The darkly shaded regions indicate filled states, and the lighter shading indicates empty states. Thus, the lowest two bands are completely filled, and the highest band is empty. The energies of all the important levels, measured from the bottom of the wells, are indicated on the diagram.



- a) (4 pts) What is the value of  $E_g$ , the energy gap between the top of the valence band and the bottom of the conduction band?

$$E_g = \text{_____} \text{ eV}$$

- b) (4 pts) The material that results from the band structure shown is a: (Circle the correct answer.)

**INSULATOR**

**CONDUCTOR**

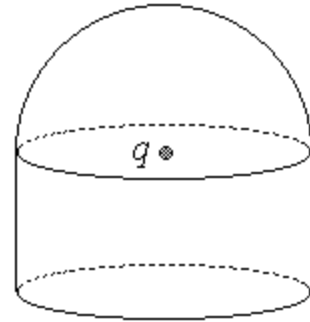
**SEMICONDUCTOR**

**IMPOSSIBLE TO DETERMINE**

NAME \_\_\_\_\_

**PART C.** (64 pts) Unless instructed otherwise, you must show all your work or state your reasoning in order to receive credit.

1. (20 pts) A Gaussian surface is constructed in the shape of a cylinder with a hemispherical top, as shown in the sketch. A charged particle, carrying a charge of  $q = 3.0 \times 10^{-9}$  C, is at the exact center of the base of the hemispherical top. The radii of the cylinder and the hemisphere are both 1.0 m, and the height of the cylinder is also 1.0 m.



- a) (6 pts) Find the value of  $\oint \vec{E} \cdot d\vec{A}$ , integrated over the entire Gaussian surface.

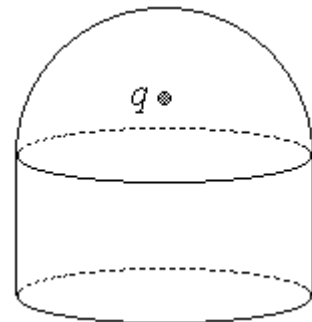
$$\oint \vec{E} \cdot d\vec{A} = \underline{\hspace{2cm}} \text{ units}$$

- b) (6 pts) Find the value of  $\int \vec{E} \cdot d\vec{A}$ , integrated over only the hemispherical top of the Gaussian surface.

$$\int \vec{E} \cdot d\vec{A} = \underline{\hspace{2cm}} \text{ units}$$

- c) (4 pts) If the charge is moved up from the center of the base of the hemisphere, but still inside the hemispherical top, as shown, the value of  $\oint \vec{E} \cdot d\vec{A}$ , integrated over the entire Gaussian surface will: (Circle the correct answer.)

**INCREASE                  DECREASE                  REMAIN THE SAME**

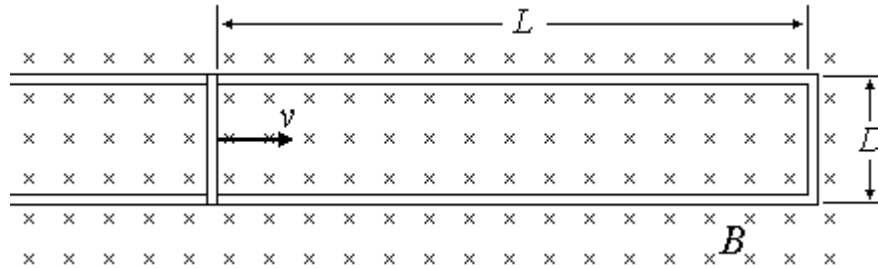


- d) (4 pts) If the charge is moved up from the center of the base of the hemisphere, but still inside the hemispherical top, as shown, the value of  $\int \vec{E} \cdot d\vec{A}$ , integrated over hemispherical top of the Gaussian surface will: (Circle the correct answer.)

**INCREASE                  DECREASE                  REMAIN THE SAME**

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2. (32 pts) The picture shows a copper rod that is forced to slide to the right, with constant speed  $v$ , along two parallel copper rails which are joined at the right end by a fixed copper rod. A constant, uniform magnetic field,  $B = 0.75 \text{ T}$ , points into the page as shown. As a result of the motion, an electromotive force of magnitude  $\mathcal{E} = 0.15 \text{ V}$  is generated in the closed loop. The separation of the two rails,  $D = 0.50 \text{ m}$ , is also the length of each of the copper rods.



- a) (4 pts) The direction of the emf in the closed loop is: (Circle the correct answer.)  
**CLOCKWISE      COUNTERCLOCKWISE      SOME OTHER DIRECTION**

- b) (7 pts) Find  $v$ , the speed at which the copper rod is forced to slide.

$v =$  \_\_\_\_\_ units

- c) (6 pts) At the instant shown in the picture, the resistance of the entire conducting loop, consisting of the parallel rails and the two rods is  $R = 4.0 \times 10^{-2} \Omega$ . Find the current that flows in the loop.

$i =$  \_\_\_\_\_ units

- d) (7 pts) At the instant shown in the picture, when the resistance of the entire conducting loop is  $R = 4.0 \times 10^{-2} \Omega$ , find  $L$ , the distance between the moving rod and the fixed rod at the end of the parallel rails. Both rods, and both rails are made of the same copper stock which has a cross sectional area of  $A = 2.0 \times 10^{-6} \text{ m}^2$ . (Hint: The resistivity of copper is  $\rho = 2.0 \times 10^{-8} \Omega \cdot \text{m}$ .)

$L =$  \_\_\_\_\_ units

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e) (4 pts) As the moving rod moves further to the right, but before it reaches the right end of the rails, the emf in the conducting loop will : (Circle the correct answer.)

**INCREASE                  DECREASE                  REMAIN THE SAME**

f) (4 pts) As the moving rod moves further to the right, but before it reaches the right end of the rails, the current in the conducting loop will : (Circle the correct answer.)

**INCREASE                  DECREASE                  REMAIN THE SAME**

3. (12 pts) Light of wavelength  $\lambda = 450 \text{ nm}$  ( $450 \times 10^{-9} \text{ m}$ ) is incident on an unknown metal. No photoelectrons are emitted.

a) (7 pts) Find energy of one of the 450 nm photons.

$E_{ph} =$  \_\_\_\_\_  
units

b) (5 pts) Do you have enough information to determine a lower limit for the work function of the metal? In other words, can you say “the work function must equal to or greater than  $\Phi_{\min}$ ”, and give a value for  $\Phi_{\min}$ ? (Circle the correct answer.)

**YES                                  NO**

If you answered **YES** determine  $\Phi_{\min}$ .

$\Phi_{\min} =$  \_\_\_\_\_  
units

If you answered **NO** briefly explain what you need to be able to determine  $\Phi_{\min}$ .