FINAL EXAMINATION

PHYS-1200 PHYSICS II MAY 9, 2006

NAME ______________________________

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

	SECTION NUMBER	EXAMINATION ROOM	INSTRUCTOR	DAY AND TIME THAT SECTION MEETS
	1	SA 3303	SCOTT DWYER	MR 8:00 A.M.
	2	SA 3303	SCOTT DWYER	MR 10:00 A.M.
	3	SA 3303	PAUL STOLER	MR 12:00 NOON.
	5	SA 3303	THOMAS SHANNON	TF 10:00 A.M.
	6	SA 3303	THOMAS SHANNON	TF 12:00 NOON
	7	SA 3303	SHAWN-YU LIN	TF 2:00 P.M.
	8	SA 3303	PAUL STOLER	MR 2:00 P.M.
	9	SA 3303	ANGEL GARCIA	MR 12:00 NOON

There are 13 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.

	CREDIT	GRADE
PART A	100 pts	
PART B	36 pts	
PART C-1	24 pts	
PART C-2	20 pts	
PART C-3	20 pts	
TOTAL	200 pts	

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

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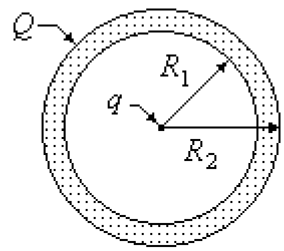
PART A. (100 pts) There are 20 questions worth 5 points each. In the space provided, to the left of the question number, write the letter corresponding to the best answer to the question.

___ 1. A positive charge Q is placed on a hollow conducting sphere of inner radius R_1 and outer radius R_2. A particle with charge q is placed at the center of the cavity in the sphere, as shown in the sketch.



The magnitude of the electric field in the cavity, at a distance r from the center ($r < R_1$) is:

A. zero B. $\frac{Q}{4\pi\varepsilon_0 R_1^2}$ C. $\frac{q}{4\pi\varepsilon_0 r^2}$ D. $\frac{(q+Q)}{4\pi\varepsilon_0 r^2}$ E. $\frac{(q+Q)}{4\pi\varepsilon_0 (R_1^2 - r^2)}$

___ 2. Increasing the separation between the plates of an isolated parallel plate capacitor, for which the charge remains constant:

A. increases the capacitance
B. increases the potential difference between the plates
C. decreases the potential difference between the plates
D. increases the electric field between the plates
E. does not change the capacitance

___ 3. A series circuit consists of a battery of electromotive force E with internal resistance r and an external resistor R. If R is adjusted, while r and E are kept constant, when $R = r$ the energy dissipated per unit time by the external resistance R is:

A. twice that by r
B. half that by r
C. a maximum
D. a minimum
E. need to know E to answer the question

___ 4. In Ampere's Law, $\oint \vec{B} \cdot d\vec{s} = \mu_0 i$, the integration must be over:

A. any closed surface
B. any surface
C. any path
D. any closed path
E. any closed path that surrounds all the current producing $\vec{B}$

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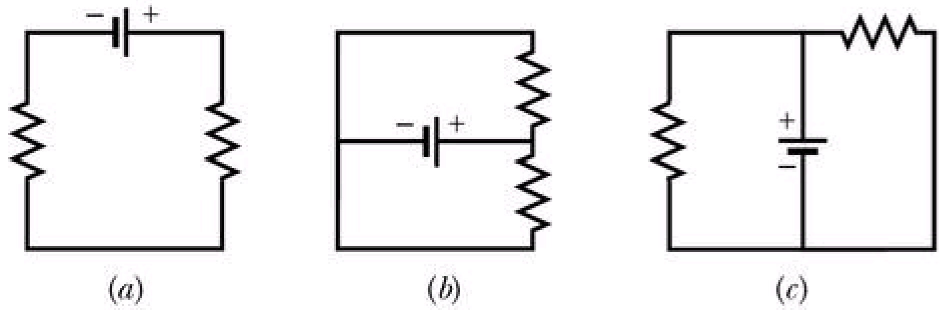
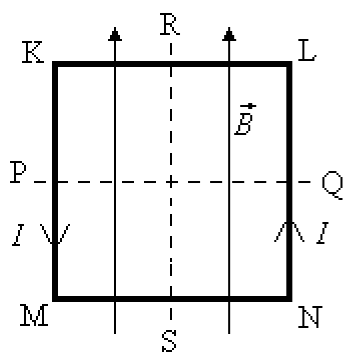
___ 5. The diagram below shows two resistors connected to a battery in three different configurations. In which cases are the resistors in series and which in parallel?



The two resistors are in:

A. parallel in (*a*), (*b*) and (*c*)
B. series in (*a*), (*b*) and (*c*)
C. parallel in (*a*), and series in (*b*) and (*c*)
D. series in (*a*), and parallel in (*b*) and (*c*)
E. parallel in (*b*), and series in (*a*) and (*c*)

___ 6. A square loop of wire lies in the plane of the page and carries a current *I* in the counterclockwise direction, as shown. There is a uniform magnetic field $\vec{B}$ parallel to the sides MK and NL and directed toward the top of the page, as indicated. The loop will tend to rotate:



A. about PQ with KL coming out of the page
B. about PQ with KL going into the page
C. about RS with MK coming out of the page
D. about RS with MK going into the page
E. about an axis perpendicular to the page

___ 7. It is impossible for two particles, each executing simple harmonic motion, to remain in phase with each other if they have different:

A. masses
B. periods
C. amplitudes
D. spring constants
E. kinetic energies

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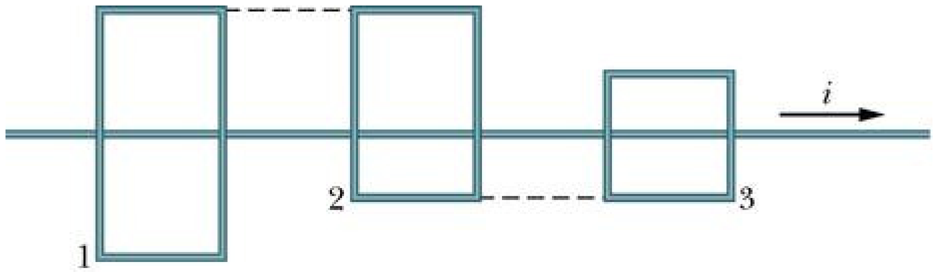
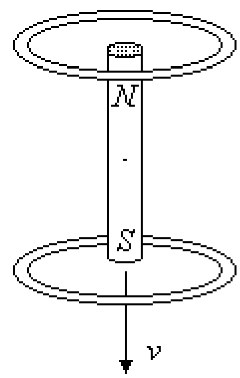
___ 8. In the figure, a long straight wire with current i passes (without touching) three rectangular wire loops with edge lengths L, $1.5L$, and $2L$. The loops are widely spaced (so as to not affect one another). Loops 1 and 3 are symmetric about the long wire. If the current i is constant, the correct ranking of the loops, based on the size of the current induced in them, is:



A. 1 > 2 > 3
B. 2 > 1 > 3
C. 1 = 3 > 2
D. 2 > 1 = 3
E. none of those given

___ 9. A vertical bar magnet is dropped through the centers of a pair of horizontal loops of wire, with the south pole leading, as shown. At the instant when the south pole is entering the lower loop, and the north pole is leaving the upper loop, the induced currents in the loops, viewed from above, are:



A. both clockwise
B. both counterclockwise
C. clockwise in the upper loop and counterclockwise in the lower loop
D. counterclockwise in the upper loop and clockwise in the lower loop
E. both essentially zero

___10. In an oscillating LC circuit, the magnitude of the rate of change of the current in the circuit, $\left|\frac{di}{dt}\right|$, is a maximum when:

A. the magnitude of the current in the inductor is a maximum
B. the magnitude of the charge on the capacitor is a maximum
C. the energy stored in the inductor is a maximum
D. the charge on the capacitor is zero
E. none of the above

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___11. Which of the following equations, along with a symmetry argument, can be used to calculate the magnetic field produced by a uniform time-varying electric field?

A. $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$

B. $\oint \vec{B} \cdot d\vec{A} = 0$

C. $\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$

D. $\oint \vec{B} \cdot d\vec{s} = \mu_0 \left(i + \varepsilon_0 \frac{d\Phi_E}{dt} \right)$

E. none of the above

___12. Three separate strings are made of the same material. String 1 has length L and is under tension τ, string 2 has length $2L$ and tension 4τ, and string 3 has length $3L$ and tension 9τ. A pulse is started at one end of each string. If the pulses start at the same time, the order in which they reach the other end is:

A. 1, 2, 3 B. 3, 2, 1 C. 2, 3, 1 D. 3, 1, 2 E. they all take the same time

___13. To which range of the electromagnetic spectrum does radiation of wavelength 200 nm (2.00×10^{-7} m) belong?

A. radio waves

B. infra-red

C. visible light

D. ultraviolet

E. x-rays

___14. When standing waves are set up in a string that is fixed at both ends, the only frequencies that the waves can have are given by the equation, $f = nf_0$, where f_0 is the fundamental frequency of the string, and n is an integer. If a standing wave is established in a string that is 6.0 m in length, with a wavelength of 2.0 m, what is the value of n?

A. 2 B. 3 C. 6 D. 8 E. some other integer.

___15. If the sound level is increased by 20 db, the intensity of the sound increases by a factor of:

A. 2 B. 5 C. 10 D. 20 E. 100

___16. The index of refraction of a material provides information about the speed of light in that material. The units of the index of refraction are:

A. m/s B. s/m C. F/m D. m/s^2 E. none of these

___17. Yellow light is being used as a source for a Young's double-slit experiment. Which of the following changes would cause the bright spots in the interference pattern to be more closely spaced?

A. Use slits that are closer together

B. Use a light source of lower intensity

C. Use a light source of higher intensity

D. Use blue light instead of yellow light

E. Use red light instead of yellow light

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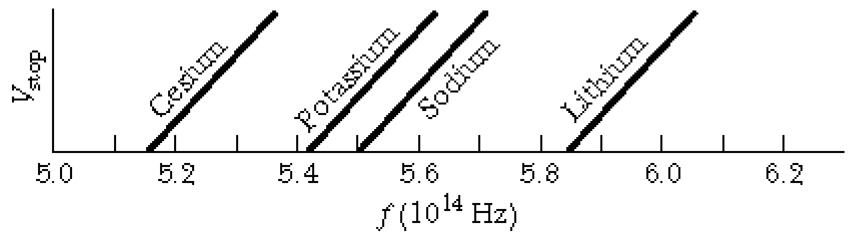
___18. The figure shows data collected in a photoelectric effect experiment. It contains graphs of stopping potential as a function of frequency of incident light for four different metals. The four lines are parallel.



The data were analyzed to get values for Planck's constant. Which metal will give the largest value for Planck's constant?
A. Cesium
B. Potassium
C. Sodium
D. Lithium
E. All four metals will give the same value for Planck's constant

___19. Consider the following three particles:
1. a free electron with kinetic energy K_0
2. a free proton with kinetic energy K_0
3. a free proton with kinetic energy $2K_0$

Rank them according to the wavelengths of their matter waves, least to greatest.
A. 1, 2, 3
B. 3, 2, 1
C. 2, 3, 1
D. 1, 3, 2
E. 1, then 2 and 3 tied

___20. For a pure semiconductor at room temperature the temperature coefficient of resistivity is determined primarily by:
A. the number of electrons in the conduction band
B. the number of impurity atoms
C. the binding energy of outer shell electrons
D. collisions between conduction electrons and atoms
E. none of the above

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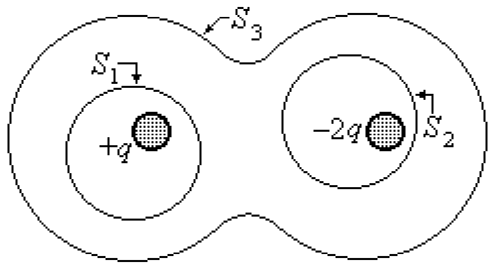
PART B. (36 pts) Write numerical answers in the spaces provided.

1. (9 pts) The shaded circles in the diagram represent two charges of unequal magnitude and opposite sign. Three Gaussian surfaces S_1, S_2, and S_3, have been constructed.



a) (3 pts) What is the net flux through surface S_1? Leave your answer in terms of q, ε_0, and any other constants that you need.

Φ_1 = ________________

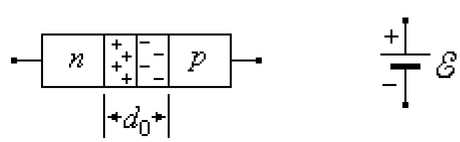
b) (3 pts) What is the net flux through surface S_2? Leave your answer in terms of q, $\varepsilon_0 0$, and any other constants that you need.

Φ_2 = ________________

c) (3 pts) What is the net flux through surface S_3? Leave your answer in terms of q, ε_0, and any other constants that you need.

Φ_3 = ________________

2. (7 pts)
   a) (3 pts) The diagram below represents a diode rectifier made from a semiconductor *p-n* junction. There is also a battery in the diagram. Draw wires on the diagram so that the battery is connected to the diode in the forward direction; that is, the direction in which current will flow easily.



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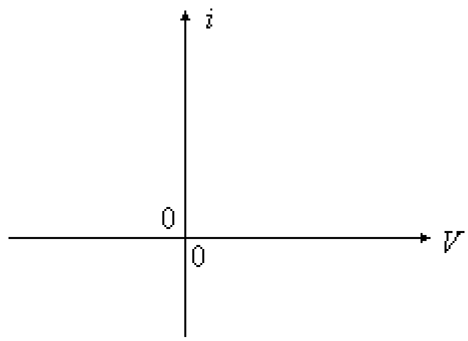
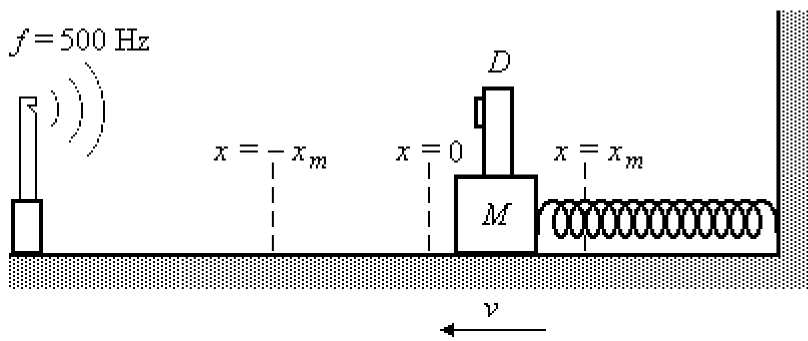
b) (4 pts) On the axes provided below, sketch a graph of the current that will flow through a *p-n* junction as a function of applied voltage. Consider both positive and negative applied voltages.



3. (12 pts) The sketch below shows a block of mass M, on a frictionless horizontal surface, and connected to a spring. The spring is at its equilibrium position when the center of mass of the block is at the spot marked $x = 0$. The block is moving in simple harmonic motion between the limits $x = x_m$ and $x = -x_m$, also marked on the sketch. A whistle that emits a sound wave of frequency 500 Hz is mounted to the left of the block, as shown. A sound detector (D) is mounted on the block. At the instant shown, the block is moving to the left.



a) (3 pts) When the center of mass of the block reaches $x = 0$, and the block is still moving to the *left*, the frequency of the sound wave detected by the detector on the block is: (Circle the correct answer)
GREATER THAN 500 Hz **LESS THAN 500 Hz** **EQUAL TO 500 Hz**

b) (3 pts) When the center of mass of the block reaches $x = -x_m$, the frequency of the sound wave detected by the detector on the block is: (Circle the correct answer)
GREATER THAN 500 Hz **LESS THAN 500 Hz** **EQUAL TO 500 Hz**

c) (3 pts) When the center of mass of the block again reaches $x = 0$, and the block is moving to the *right*, the frequency of the sound wave detected by the detector on the block: (Circle the correct answer)
GREATER THAN 500 Hz **LESS THAN 500 Hz** **EQUAL TO 500 Hz**

d) (3 pts) When the center of mass of the block reaches $x = x_m$, the frequency of the sound wave detected by the detector on the block is: (Circle the correct answer)
GREATER THAN 500 Hz **LESS THAN 500 Hz** **EQUAL TO 500 Hz**

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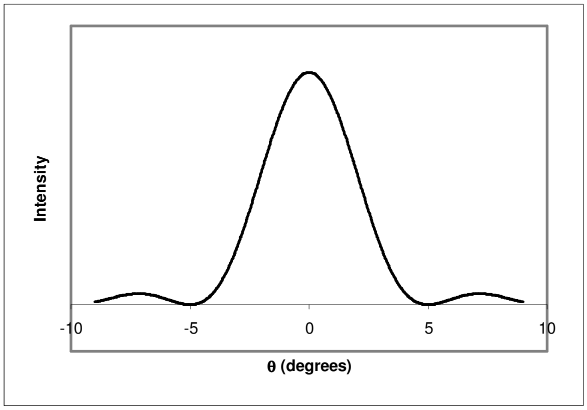
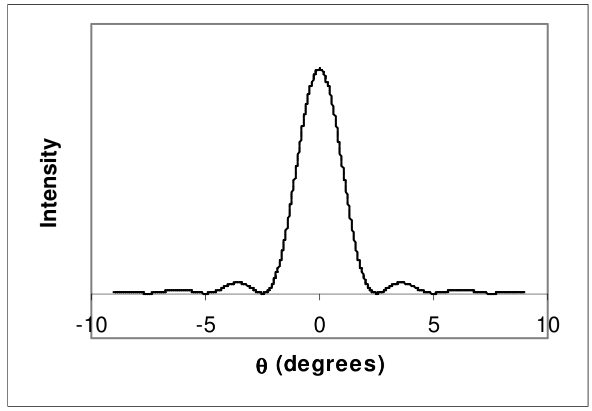
4. (8 pts) The graphs below show the diffraction patterns as a function of angle, produced by two beams of electrons that have passed through the same narrow slit at different times.



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**

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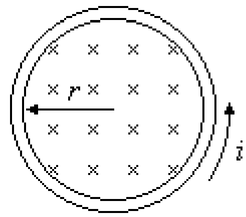
PART C. (64 pts) Unless instructed otherwise, you must show all your work or state your reasoning in order to receive credit.

1. (24 pts) The sketch shows a circular loop of copper wire that encloses a changing magnetic field. The changing magnetic field induces an emf in the loop of wire, and a current flows in the counterclockwise direction, as shown.



a) (5 pts) Indicate whether the magnitude of the magnetic field enclosed by the wire is increasing or decreasing by circling the correct statement below. No work need be shown. (Hint: the induced current is in the counterclockwise direction.)

THE MAGNETIC FIELD IS INCREASING

THE MAGNETIC FIELD IS DECREASING

b) (9 pts) The emf induced in the wire is $\mathcal{E}$ = 0.020 V, and the resulting current is i = 5.0 A. Find the resistance of the wire.

R = ____________ ____
units

c) (10 pts) Find the magnitude of the rate at which the magnetic field is changing. As before, the induced emf is $\mathcal{E}$ = 0.020 V, and the radius of the wire circle is r = 0.10 m.

$\left|\frac{dB}{dt}\right|$ = ____________ ____
units

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2. (20 pts) An oscillating *LC* circuit in a certain timing device is supposed to have a period of oscillation of $T = 1.00 \times 10^{-3}$ s. However, it was built with components of the following values: $L = 1.60 \times 10^{-2}$ H, and $C = 2.00 \times 10^{-6}$ F.

a) (6 pts) Find the period of oscillation of the *LC* circuit.

T = _____________ ____ units

b) (4 pts) It is possible to reduce the period of oscillation to the desired value by adding another capacitor to the circuit. How should the new capacitor be added to the circuit? (Circle the correct answer.)
(If your answer to part (a) is not higher than 1.00×10^{-3} s, you should check your work.)

IN SERIES WITH THE OTHER CAPACITOR

IN PARALLEL WITH THE OTHER CAPACITOR

c) (10 pts) Find the value of the capacitor that must be added to the circuit to give it a period of oscillation of 1.00×10^{-3} s.

C' = _____________ ____ units

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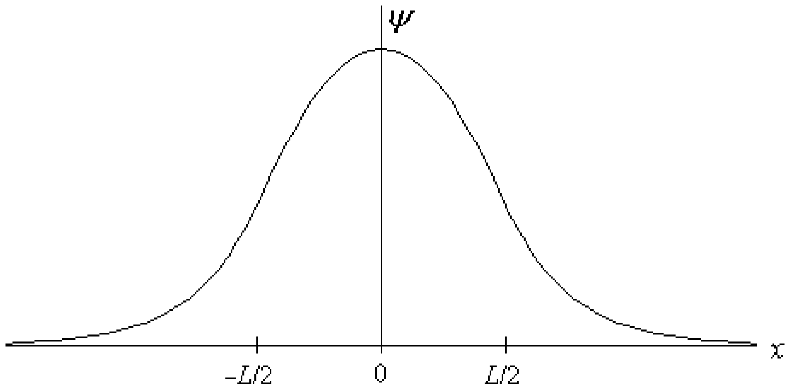
3. (20 pts) The sketch shows the ground state wave function for an electron trapped in a finite square well. The width of the well is L, and extends from $x = -L/2$ to $x = L/2$.



The form of the wave function outside the well is not the same as inside the well. Then:

for $x = -\infty$ to $x = -L/2$, $\psi_1(x) = Ae^{\alpha x}$

for $x = -L/2$ to $x = L/2$, $\psi_1(x) = B\cos kx$

for $x = L/2$ to $x = \infty$, $\psi_1(x) = Ae^{-\alpha x}$.

In this case, the depth of the well is $U_0 = 0.20$ eV and the width is $L = 2.0$ nm (2.0×10^{-9} m).
The energy of the ground state is $E_1 = 0.0445$ eV.
The values of the constants in the wave functions are:

$A = 9.18 \times 10^4\ \text{m}^{-1/2}$, $B = 2.59 \times 10^4\ \text{m}^{-1/2}$, $\alpha = 2.02 \times 10^9\ \text{m}^{-1}$, $k = 1.08 \times 10^9\ \text{m}^{-1}$

a) (5 pts) Find the wavelength of the electron when it is within the well, in its ground state.

λ = ____________ ____
units

NAME ______________________________

b) (10 pts) Find an expression for the probability of finding the electron between $x = L/2$ and $x = \infty$. You need not evaluate this expression numerically. Just leave it in terms of the constants given in the problem (A, B, α, k, L, etc.).

$P(L/2 < x < \infty) =$ ___________________

c) (5 pts) Once you have determined the probability of finding the electron between $x = L/2$ and $x = \infty$ $\{P(L/2 < x < \infty)\}$, it is possible to evaluate the probability of finding the electron within the well, between $x = -L/2$ and $x = L/2$ $\{P(-L/2 < x < L/2)\}$, without further integration. That is because the probabilities are related by: (Circle the correct choice.)

$P(-L/2 < x < L/2) = P(L/2 < x < \infty)$

$P(-L/2 < x < L/2) = 2P(L/2 < x < \infty)$

$P(-L/2 < x < L/2) = 1 - P(L/2 < x < \infty)$

$P(-L/2 < x < L/2) = 1 - 2P(L/2 < x < \infty)$

$P(-L/2 < x < L/2) = \frac{3}{2} P(L/2 < x < \infty)$

$P(-L/2 < x < L/2) = \frac{1}{2} [1 - P(L/2 < x < \infty)]$