Physics 228 - Exam 2
7 April 2011
Profs. Rabe and Coleman

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Your name sticker with **exam code**

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SIGNATURE ____________________

Turn off and put away cell phones now!

1. The exam will last from 9:40pm to 11:00pm.
2. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
3. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
4. Under STUDENT # enter your 9-digit student ID.
5. Enter 228 under COURSE, and your section number (see label above) under SEC.
6. Under CODE enter the exam code given above.
7. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
8. There are 16 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the ened of the exam, **hand in the answer sheet and the cover page.** Retain this question paper for future reference and study.
9. When you are asked to open the exam, make sure that your copy contains all 16 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
10. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

Useful information

c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602×10^{-19} Coulombs
$q_p = +e$ = charge on a proton = $+1.602 \times 10^{-19}$ Coulombs
m_e = electron mass = 9.11×10^{-31} kg
$m_e c^2$ = electron rest energy = 0.511 MeV
m_p = proton mass = 1.67×10^{-27} kg
$m_p c^2$ = proton rest energy = $938.27 MeV$
$m_n c^2$ = neutron rest energy = $939.57 MeV$
k_B = Boltzmann's constant = 1.38×10^{-23} J/K
Wien's Constant = $2.898 \times 10^{-3} m \cdot K$
σ = Stefan's Constant = $5.670 \times 10^{-8} W/(m^2 K^4)$
$\hbar = \frac{h}{2\pi}$
$h = 6.626 \times 10^{-34}$ J-s
$h = 4.136 \times 10^{-15}$ eV-s (in units of electron volts-second)
hc = 1240 eV $\cdot$ nm = 1240 MeV $\cdot$ fm
1 MeV/c = 5.36×10^{-22} kgm/s
1 nm = 10^{-9} m
1 Å = 10^{-10} m = 0.1 nm
1 μm = 10^{-6}m
1 mHz = 10^{-3} Hz   1 kHz = 10^{+3} Hz
1 MHz = 10^{+6} Hz   1 GHz = 10^{+9} Hz

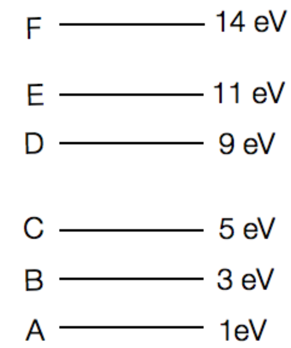
1. The Heisenberg uncertainty principle places a fundamental limit on:
   a) the speed of light in a vacuum.
   b) the wavelength of a particle.
   c) the resolution of microscopes.
   d) simultaneous determination of the position and momentum of a particle.
   e) measurement of a particle's momentum.

2. A lithium atom, mass 1.17×10^{-26}kg, is vibrating with simple harmonic motion in a crystal lattice, where the force constant k is 85.0N/m. What is the ground-state energy of this system in eV?
   a) 0.35 eV
   b) 0.056 eV
   c) 0.175 eV
   d) 0.028 eV
   e) 2.2 eV

3. A hydrogen atom at rest is in a state of quantum number n=6. The electron jumps to a lower state, emitting a photon of energy 1.13 eV. What is the quantum number of the state to which the electron jumped?
   a) 2
   b) 3
   c) 5
   d) 1
   e) 4

4. A particle initially moving with speed 0.6 c has its speed increased by a factor 4/3. What is $KE_{final}/KE_{initial}$?
   a) 4/5
   b) 8/3
   c) 1/2
   d) 16/9
   e) 3/8

5. The energy levels for a hypothetical system are as shown. If a photon of frequency $f = 2.67 \times 10^{15}$ Hz is *absorbed* by the system, which of the following transitions takes place?



   a) B $\rightarrow$ E
   b) F $\rightarrow$ B
   c) E $\rightarrow$ A
   d) A $\rightarrow$ E
   e) B $\rightarrow$ F

6. K-mesons have an average proper lifetime τ_P. How fast must they move so that their average lifetime is $1.5\tau_P$?
   a) 0.67c
   b) 0.90c
   c) 0.75c
   d) 0.56c
   e) 0.40c

7. The photoelectric work functions of certain metals are as follows: sodium 1.82 eV, calcium 2.9 eV, uranium 3.6 eV and copper 4.7 eV. Which of these metals could *not* emit photoelectrons when irradiated with visible light (wavelength 400-700 nm)?
   a) copper
   b) calcium, uranium and copper
   c) sodium
   d) copper and uranium
   e) sodium and calcium

8. Two events take place simultaneously, but 3000km apart. What is the time interval between the two events measured by an observer moving at speed $\frac{5}{13}c$ along the line separating the two events?

a) $1.25 \times 10^6 s$
b) 4.17 ms
c) 10.0 ms
d) 3.55 ms
e) 3.85ms

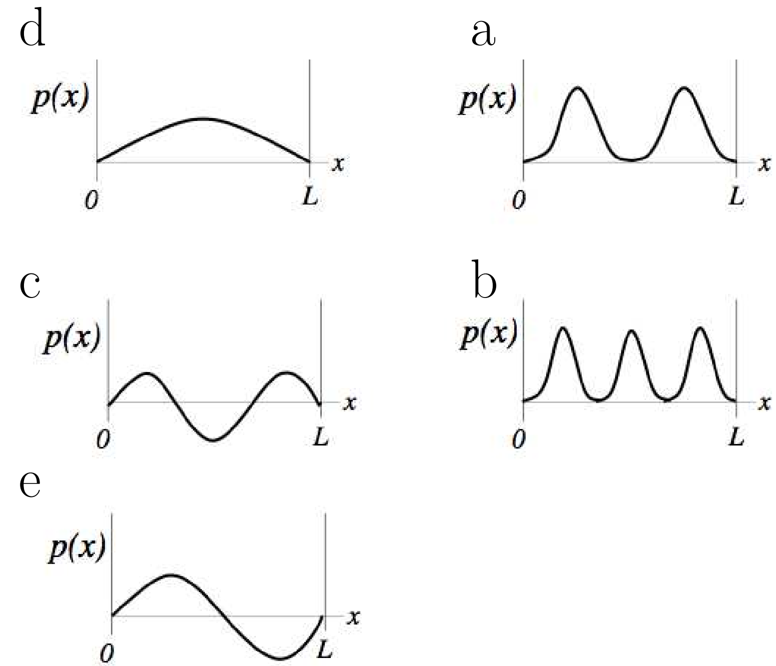
9. An electric current through a tungsten filament maintains its temperature at 2800 K. Assume the tungsten filament behaves as an ideal blackbody at that temperature. If the effective radiating area of the filament, as an ideal radiator, is 2.0×10^{-6} m^2, the total power radiated by the filament is closest to:

a) 3.5 MW
b) 8.9 $\times 10^{-7}$W
c) 10.1 W
d) 5.1 MW
e) 7.0 W

10. An electron has a de Broglie wavelength of 0.2 nm. What is its kinetic energy?

a) 38 eV
b) 314 eV
c) 6.2×10^3 eV
d) 6.0×10^{-3} eV
e) 1.3 eV

11. A particle in a box of length L is in the $n = 3$ state. Which diagram in the figure best describes its probability distribution $p(x)$?



12. A particle in a one-dimensional box (with $V = 0$ between infinitely high side walls) has a ground-state energy of 2 eV. In the first two excited states, the particle's energy would be respectively

a) 4 eV and 8 eV
b) 8 eV and 18 eV
c) 4 eV and 6 eV
d) 3 eV and 4 eV
e) None of the other answers

13. An enemy spaceship is moving toward your starfighter with a speed, as measured in your frame, of $0.400c$. The enemy ship fires a missile toward you at a speed of 0.700 c relative to the enemy ship. What is the speed of the enemy missile relative to you?

a) $0.3c$
b) $0.41c$
c) $1.52c$
d) $0.86c$
e) $1.1\ c$

14. A particle with spatial wave function $\psi(x) = Ae^{ikx}$ where $k = 10^{14}$ m^{-1} has momentum : (note: 1 MeV/c = 5.36 $\times 10^{-22}$kg m/s)

a) 10^{12} MeV/c
b) 19.7 keV/c
c) 19.7 MeV/c
d) 10^{14} MeV/c
e) 0.07 MeV/c

15. The time-dependent Schroedinger equation for a particle moving in one dimension is given by

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2} + U(x)\psi(x,t) = -i\hbar\frac{\partial\psi(x,t)}{\partial t}$$

Which the of the following statements is true?

a) The term $-\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2}$ is associated with the potential energy.
b) The term $U(x)\psi(x,t)$ is associated with kinetic energy.
c) In a stationary state $\psi(x,t)$ does not depend on t.
d) In a stationary state with energy E, $-i\hbar\frac{\partial\psi(x,t)}{\partial t} = E\psi(x,t)$.
e) The term $-i\hbar\frac{\partial\psi(x,t)}{\partial t}$ is usually unimportant.

16. A cube of metal with sides of length a sits at rest in a frame S with one edge parallel to the x-axis. In S the cube has volume a^3. Frame S' moves along the x-axis with a speed u. As measured by an observer in frame S', what is the volume of the metal cube?

a) $a^3/\sqrt{1-\frac{u^2}{c^2}}$
b) $\left(a/\sqrt{1-\frac{u^2}{c^2}}\right)^3$
c) $\left(a\sqrt{1-\frac{u^2}{c^2}}\right)^3$
d) $a^3\sqrt{1-\frac{u^2}{c^2}}$
e) a^3