Problem	Score
1	
2	
3	
Net	

PH 1130: INTRODUCTION TO 20^{TH} CENTURY PHYSICS
C TERM, 2008
KOLECI

NAME (please include last name):__________________________
SECTION NUMBER:______________

SAMPLE EXAM I
2 PM – 2:50 PM
CLOSED BOOK EXAM

PLEASE ANSWER ALL THREE QUESTIONS IN THE SPACE PROVIDED. QUESTIONS ONE AND TWO ARE WORTH 35 POINTS, EACH. QUESTION THREE IS WORTH 30 POINTS. PLEASE BE SURE TO SHOW ALL WORK AND JUSTIFY ALL YOUR ANSWERS. GRADING WILL BE BASED ON EVIDENCE OF YOUR UNDERSTANDING OF THE BASIC CONCEPTS AND PRINCIPLES—PLEASE PROVIDE THOROUGH SOLUTIONS TO THE PROBLEMS. GOOD LUCK!

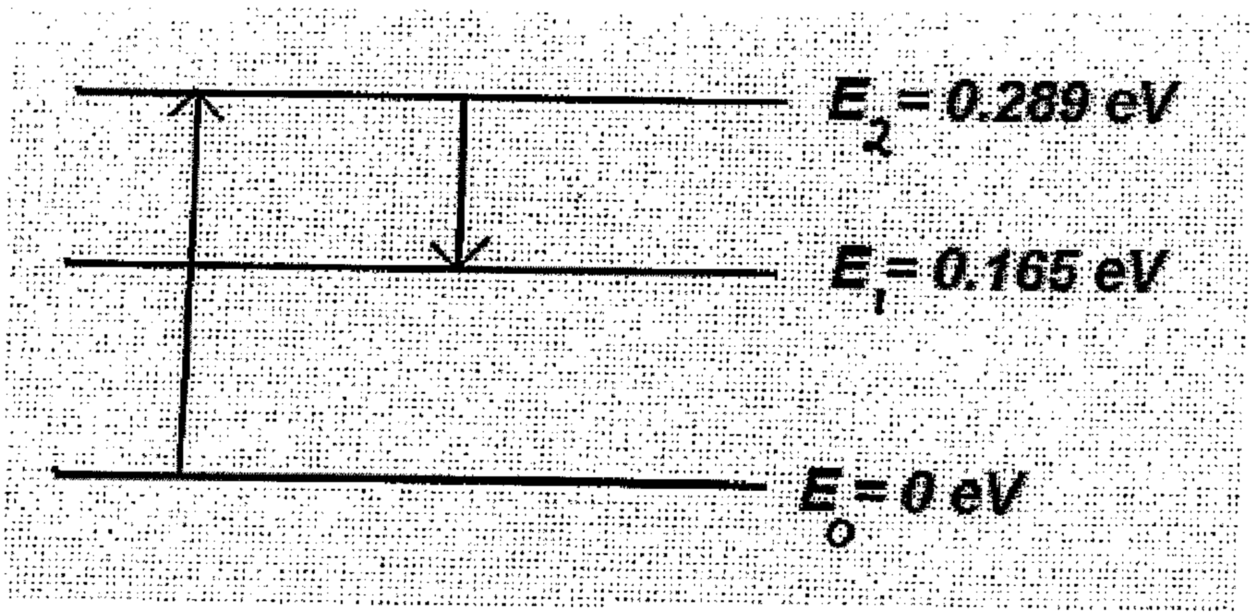
Possibly Useful Information:

$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/Nm^2$
m_e = mass of electron $= 9.11 \times 10^{-31}$ kg
q_p = charge of proton $= 1.6 \times 10^{-19}$ C
$F = (1/4\pi\varepsilon_o)(q_1 q_2/r^2) = k(q_1 q_2/r^2)$
$\mathbf{E} = \mathbf{F}/q$
1 eV $= 1.6 \times 10^{-19}$ J
$\sigma = 5.67 \times 10^{-8}\ W/(m^2 K^4)$
$x = x' + ut,\ y' = y,\ z' = z$
$l = l_o/\gamma = l_o(1 - (u^2/c^2))^{1/2}$
$t' = \gamma(t - (ux/c^2))$
$\vec{p} = \gamma m\vec{v}$
$F = \gamma^3 ma$ (F & v along same line)
$E = K + mc^2 = \gamma(mc^2)$
$E^2 = (mc^2) + (pc)^2$
$E = hf = h(c/\lambda)$
$P = E/c = (hf)/c = h/\lambda$
$R = 1.097 \times 10^7\ m^{-1}$
$E_n = (-hcR)/n^2$
Paschen Series: $(1/\lambda) = R(1/3^2 - 1/n^2)$ $n = 4,5,6\ldots$
Brackett Series: $(1/\lambda) = R(1/4^2 - 1/n^2)$ $n = 5,6,7\ldots$
Pfund Series: $(1/\lambda) = R(1/2^2 - 1/n^2)$ $n = 6,7,8\ldots$
$L_n = mv_n r_n = nh/(2\pi)$
$v_n = e^2/(2nh\,\varepsilon_o)$
$\lambda' - \lambda = [h/(mc)](1 - \cos\varphi)$
$\lambda_m T = 2.90 \times 10^{-3}$ m K

q_e = charge of electron $= 1.6 \times 10^{-19}$ C
m_p = mass of proton $= 1.67 \times 10^{-27}$ kg
$c = 3.00 \times 10^8$ m/s
$E = k(q/r^2) = (1/4\pi\varepsilon_o)(q/r^2)$
$h = 6.626 \times 10^{-34}$ Js
$k = 1.381 \times 10^{-23}$ J/K
$\gamma = (1 - (u^2/c^2))^{-1/2}$
$\Delta t = \gamma(\Delta t_o) = (\Delta t_o)/(1 - (u^2/c^2))^{1/2}$
$x' = \gamma(x - ut),\ y' = y,\ z' = z$
$v_x = (v_x' + u)/(1 + (u v_x'/c^2))$
$a = (F/m)(1 - (v^2/c^2))^{3/2}$
$F = \gamma ma$ (F & v perpendicular)
$K = (\gamma - 1)(mc^2)$
$(pc)^2 = K^2 + 2K(mc^2)$
$\frac{1}{2} mv^2 = eV_o = hf - \varphi$
$hf = E_i - E_f$
Balmer Series: $(1/\lambda) = R(1/2^2 - 1/n^2)$ $n = 3,4,5\ldots$
Lyman Series: $(1/\lambda) = R(1/1^2 - 1/n^2)$ $n = 2,3,4\ldots$
$r_n = \varepsilon_o[(nh)^2/(\pi me^2)]$
$eV_{AC} = hf_{max} = (hc)/\lambda_{min}$
$I = \sigma T^4$
$I(\lambda) = (2\pi hc^2)/(\lambda^5)[e^{hc/\lambda kT} - 1]^{-1}$

Problem One (*35 points*): An armada of spaceships that is Λ meters long (in its rest frame) moves with speed μc relative to a ground station in frame S (here μ is a positive constant less than one) . A messenger travels from the rear of the armada to the front with a speed δc relative to S (here δ is a positive constant less than one). (a) How long does the trip take as measured in the messenger's rest frame? *(10 points)* (b) How long does the trip take as measured in the armada's rest frame? *(10 points)* (c) How long does the trip take as measured by an observer in frame S? *(10 points)* (d) Briefly explain time dilation. *(5 points)*

Problem Two (*35 points*): *Martian CO_2 laser:* Where sunlight shines on the atmosphere of Mars, carbon dioxide molecules at an altitude of about *75 km* undergo natural laser action. The energy levels involved in the action are shown in the figure below; population inversion occurs between energy levels E_2 and E_1. (a) What wavelength of sunlight excites the molecules in the lasing action? (b) At what wavelength does lasing occur? (c) In what region of the electromagnetic spectrum do the excitation and lasing wavelengths lie?



Problem Three: Conceptual Questions: Please answer the following possibly unrelated questions, using a minimum of mathematics *(6 points each, 30 points total).*

a. The premise of the *Planet of the Apes* movies and book is that hibernating astronauts travel far into Earth's future, to a time when human civilization has been replaced by an ape civilization. Considering only special relativity, determine how far into Earth's future the astronauts would travel if they slept for σ years (here σ is some positive number) while traveling relative to Earth with a speed of τc (here τ is a positive number less than one but close enough (to one) to make the problem relativistic), first outward from Earth and then back again.

b. What is a photon? What is the momentum of a photon equal to?

c. In the photoelectric effect, briefly describe the stopping potential? Briefly describe the work function.

d. Briefly describe an ideal blackbody. To what power of temperature is intensity proportional to?

e. **Assessment Questions:** A guaranteed six points for answers you provide!

- Did you write your <u>name</u> on the exam (If No, please do so now!)?
- What was the <u>most</u> challenging (*aka: difficult*) topic we studied so far?
- What was the <u>least</u> challenging (*aka: easiest*) topic we studied so far?
- What was <u>most</u> helpful, in preparation for this exam?
- What was <u>least</u> helpful, in preparation for this exam?
- On a scale of 1-5, 5 = identical, 3 = neutral, and 1= very different, how would you rate the sample exam with the actual exam?