University of California at Berkeley

Physics 7C Lecture 1 **Professor Lin** **Spring 2008**

Second Midterm Examination **Monday, 7 April 2008, 6:00 –8:00 PM**

Print Name _____ Discussion Section #

Signature _____ Discussion Section GSI

Student ID# _____

This exam is closed book, but you are allowed one 8.5" x 11" (double-sided) page of handwritten notes. You may use a calculator, however NO wireless calculators are allowed. **Anyone using a wireless calculator will forfeit their exam and automatically receive the score of zero.**

a) Write your name, Discussion Section #, GSI name and SID# on the top of all materials you intend to hand in and want to be graded.
b) Remember to circle all of your final answers.
c) Express all numerical results to 3 significant figures. Cross out any work you decide is incorrect, with an explanation in the margin.

Read through the entire exam to start. Work to maximize your credit — try to obtain at least partial credit on every part of every problem. Do your work clearly so we can easily follow. Show *all* work, using the front and back sides of this exam paper. If you do not show relevant work for any part of a problem, you will not be awarded any credit, even if the answer is correct. If you recognize that an answer does not make physical sense and you do not have time to find your error, write that you know that the answer cannot be correct and explain how you know this to be true. (We will award some credit for recognizing there is an error.) Do not get bogged down in algebra — if you have enough equations to solve for your unknowns, box the equations, state how you would finish, and move on (you can go back and complete the algebra later if you have time). And if you have questions about the interpretation of a problem, *please ask!*

Problem 1	
2	
3	
4	
5	
TOTAL	

Total of 100 points (points for each part indicated in problem).

DO NOT TURN TO NEXT PAGE UNTILTHE PROCTOR TELLS YOU TO START!

1. The Hubble Space Telescope (HST) is a reflecting telescope of 2.4 meters diameter.
   (a) Suppose HST is observing a double star 10 light-years away. What is the minimum separation of the two stars for their images to be resolved (Assume a wavelength of 500nm). (10 points)
   (b) If the focal length of HST is 4 m, how far apart are the centers of the images of the two stars in the focal plane of HST? (5 points)
   (c) Suppose the camera at the focal point of HST can detect sources with intensity above 10 photons/sec. How far away can a star as bright as the Sun be detected by HST? The Sun's luminosity is 4×10^{26} watts. Assume all this radiation is at λ=500nm. (5 points)

2. Two polarizing sheets have their transmission axes crossed so no light gets through. A third sheet is inserted in between so that its transmission axis makes an angle θ with that of the first sheet. If the middle polarizing sheet is rotating at an angular velocity ω about an axis parallel to the light beam, find the intensity transmitted through all three sheets as a function of time. Assume that $\theta = 0$ at time $t = 0$, and that unpolarized light of intensity I_0 is normally incident on the first sheet. (20 points)

3. The decay products of a nucleus of rest mass M^* include another nucleus of rest mass M ($M < M^*$) and a photon. If the decaying nucleus is at rest, use conservation of momentum and energy to find an expression for the kinetic energy of the remnant nucleus of mass M in terms of M and M^*. (20 points)

4. A friend travels by you in her fast sports car at a speed of 0.760c. It is measured in your frame to be 5.80 m long and 1.45 m high. (5 points for each part, total 20 points)
   (a) What will be its length and height at rest?
   (b) How many second elapsed on your friend's watch when you see 20.0 s has passed on yours?
   (c) How fast were you traveling according to your friend?
   (d) How many seconds do you see elapsed on your watch when ~~she saw~~ 20.0 s pass on hers?

you see

5. A Sun-like star, traveling at speed u = 0.8c in a direction perpendicular to the line to the observer, emits in the hydrogen alpha line (rest wavelength, 121.6 nm). ($M_{sun} = 2 \times 10^{30}$ kg, $R_{sun} = 7 \times 10^{8}$ meters).

(a) Determine the wavelength seen by the observer (hint: use the Lorentz transformation). (10 points)

(b) Determine the wavelength seen if the observer is on the surface of a neutron star with mass M = 1.5 M_{sun} and radius R = 10 km. Explain your answer. (10 points)