*NAME*______________________

MIDTERM

Physics 141 Fall Quarter 2007 H.J.Frisch HEP320 (702-7479) Oct. 30, 2007

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(60 min: 4 questions) Make a good clear picture before you do anything, and show your work! Much partial credit will be given for setting up the problem correctly, but we gotta be able to figure out what you're doing. Random chicken-scratching will be ignored or worse. Good Luck!

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Problem 1 (10 points)

1. Find the explicit representation (i.e. the matrix) for the Lorentz transformation corresponding to first transforming from a frame F moving at velocity β along the x' direction in a frame F', followed by a transformation from F' to a frame F", in which F'is moving along the y" direction (assume all 3 origins coincide at t=t'=t"=0, and at that time all 3 sets of axes point in the same direction.

2. Find γ for the combined transformation.

3. Find β.

Problem 2 (10 points) Consider a distant galaxy moving away from us at velocity $\beta = 0.866$, i.e. $\gamma = 2$. A photon is emitted from the galaxy with energy E.

1. Draw a picture with labeled axes for the two frames involved and showing the relative velocity β.

2. Use the Lorentz Transformation to express the energy of the photon we observe (i.e. in the Earth's frame) in terms of E and β (only- these should be the only two variables in your final formula)..

3. (Optional- worth 2 pts extra credit) The energy of a photon goes inversely with its wavelength. i.e. $E \propto 1/\lambda$, where λ is the wavelength, often measured in nanometers (nm). The wavelength of the most energetic (shortest wavelength) line from excited Hydrogen atoms is 121.6 nm (the 'Lyman alpha line'). For the galaxy described above, at what wavelength will it be observed?

Problem 3 (10 points) You measure the volume of a floor tile (i.e. something square, flat, and thin in the vertical dimension) by measuring the two sides of the square with a cheap plastic ruler, and the thickness with a precision calipers (an instrument for measuring thicknesses). The nominal dimensions of the floor tile are 10" by 10" by 1/4", but in real life can vary from nominal. The plastic ruler can be read to an accuracy 1/10"; the caliper is good to 1 mil (0.001"). Calculate the volume and the uncertainty on the volume from the individual measurements assuming:

1. The three measurements are uncorrelated (use $A = x \times y \times z$);

2. Measurements with the plastic ruler are systematically off in the same direction, with the same rms (root-mean-square) uncertainties as in Part 1 (use (use $A = L^2 \times z$, where L is either x or y).

Problem 4 (10 points) A Z-boson (sibling of the photon, but with mass) is created at rest in a proton-antiproton collision at Fermilab. It decays into an electron (e^-) and a positron (e^+). The mass of the Z-boson is measured to be 91 GeV; the mass of the electron (and of the positron) is 0.0005 GeV, and can be neglected (set to zero).

1. Find the momentum of the electron after the Z-boson decay. (Please don't plug in numbers until the very end, and show your work line-by-line).

2. Assume that instead the Z-boson was moving with an energy E = 182 GeV, and in the Z rest-frame the electron and positron emerge each at 90-degrees from the direction that the Z is moving in as seen from the lab frame. Find the 4-momenta of the electron and positron in the lab frame.