Physics 205 Test 3

I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Name _____ Signature _____

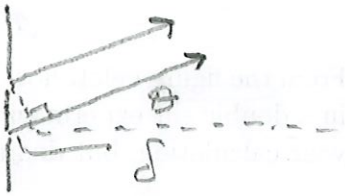
Questions (7 for 7 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. If the momentum of a particle going close to the speed of light doubles does the velocity double? Explain.

No. Relativistic momentum is $\vec{p} = \frac{m\vec{v}}{\sqrt{1 - v^2/c^2}}$. The denominator depends on v so doubling the left-hand side does not double the velocity.

2. If you move from one bright fringe in a double-slit interference pattern to the next one out from the central maximum, does the path length difference δ increase, decrease, or stay the same? If it changes, by how much in terms of wavelength λ? Explain.

The path difference increases by λ to get to the next constructive interference configuration.

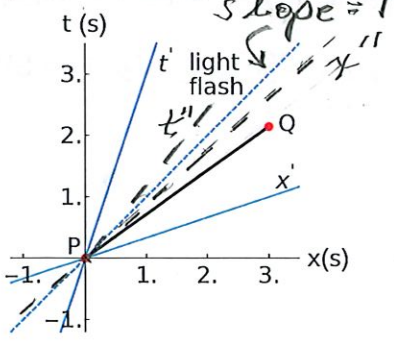


3. A system consists of two photons moving in opposite directions, one with energy E and the other with energy $4E$. What is the system's total mass? Explain.

$$\vec{p}_{total} = (E, 0, 0, E) + (4E, 0, 0, -4E) = (5E, 0, 0, -3E)$$

$$m = \left[(5E)^2 - (-3E)^2\right]^{1/2} = 4E$$

4. The figure below shows a two-observer, spacetime diagram. It is claimed that the points P and Q are causally connected. Is that true or false? Explain.



False. The slope of $\overline{PQ} = \frac{1}{v} < 1$ so $v > c$ so they cannot be causally connected.

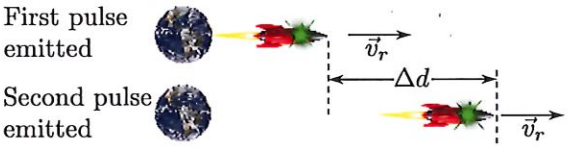
OR

The t'' vs. x'' axes drawn as dashed lines show a frame where event Q comes before event P.

5. A sealed cup of water is placed inside a microwave oven. The water absorbs microwave energy which causes its atoms to vibrate more vigorously making the water warmer. What happens to the mass of the water in the cup? Explain.

The weight of the cup of water increases because the particles move faster and $E = mc^2/\sqrt{1-v^2/c^2}$ so the relativistic mass increases.

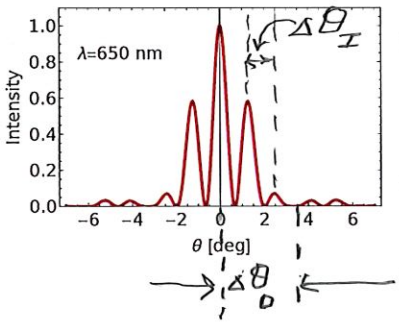
6. Answer this question non-relativistically. An observer on the (roughly) stationary Earth watches a spaceship traveling away and towards the galactic core at a speed v_r. The craft emits a burst of light from a beacon that is later observed by the Earthbound observer. After a proper time interval Δt_{rocket} as measured by the captain of the spaceship, another burst of light is emitted. A schematic drawing of the two events is shown below. The ship travels a proper distance Δd between pulses as measured by the Earthbound observer. How long is the time interval between light pulses as measured by the Earthbound observer in terms of v_r, Δt_{rocket}, and Δd?



$\Delta t_{Earth} = \Delta t_{rocket} + \frac{d}{c}$

Time for light to cover the additional distance between pulses

7. From the figure below how would you determine the size of the slits and their separation in a double slit experiment? You should use the plot to define the numerical inputs to your calculation, but don't actually do any calculations.



The angle $\Delta\theta_I \approx 1.5°$ between bright spots is from interference between waves from the slits. Use $\lambda = d \sin\theta_I$ where d is the slit separation. The angle $\Delta\theta_D \approx 3.3°$ is from diffraction at each opening so $\lambda = a \sin\theta_D$ where a is the size of the slit.

Problems (4). Clearly show all reasoning for full credit. Use a separate sheet for your work.

1. 8 pts. A particle has 4-momentum $\underset{\sim}{p} = [p_t, p_x, p_y, p_z] = [5\ kg, 0, 3\ kg, 0]$ in SR units. What is the particle's mass?