Homework #10 (100 points) - Show all work on the following problems:
(Grading rubric: Solid attempt = 50% credit, Correct approach but errors = 75% credit, Correct original solution = 100% credit, Copy of online solutions = 0% credit)

Problem 1 (20 points): A boat has a mast that is tipped backward from vertical, making an angle of θ with respect to the horizontal deck. If the boat travels at relativistic speed v past a dock, what angle between the mast and the deck does a stationary observer on the dock report?

Problem 2 (20 points): Solve the Lorentz transformations for x',y',z',t' in terms of x,y,t,z (Eq. 12.18) to obtain the reverse transformation for x,y,t,z in terms of x',y',z',t' (Eq. 12.19).

Problem 3 (40 points): In reference frame S, a static uniform line charge λ extends along the z-axis.

3a (10 points). Write the electric field in S, in Cartesian coordinates x,y,z.

3b (10 points). Find the electric field in a frame S' that moves with speed u in the x-direction with respect to S, in terms of x,y,z.

3c (10 points). Express your answer in terms of the S' coordinates x',y',z'.

3d (10 points). Express your answer in terms of a vector from the present location of the wire, and the angle θ between that vector and a unit vector in the x' direction. Is the field still radially outward from the instantaneous location of the wire?

Problem 4 (20 points):

4a (10 points). Show that the dot product between the electric and magnetic fields is invariant (i.e. does not change under transformations between reference frames).

4b (10 points). Show that the quantity $(E^2-c^2B^2)$ is invariant.