

PROBLEM 1

i) THE SPEED OF LIGHT IN VACUUM IS A RELATIVISTIC INVARIANT. THAT IS, INERTIAL OBSERVERS MEASURE THE SAME VALUE FOR THE SPEED OF LIGHT IN VACUUM, IRRESPECTIVE OF THEIR (CONSTANT) RELATIVE MOTION.

ii) THE COVARIANCE (INVARIANCE IN FORM) OF THE LAWS OF PHYSICS. THAT IS, THE FORM OF THE EQUATIONS OF MOTION IS IDENTICAL FOR ALL INERTIAL OBSERVERS, IRRESPECTIVE OF THEIR (CONSTANT) RELATIVE MOTION.

PROBLEM 2

$$V = \frac{(V_b + V_t)}{(1 + V_b V_t / c^2)} ; \quad \mathcal{F} = \mathcal{F}_b + \mathcal{F}_t$$

RECALL $v/c = \tanh(\mathcal{F})$

PROBLEM 3

$$X_{A,1}^M = (15, 5, 3, 0) ; \quad X_B^M = (5, 10, 8, 5)$$

THUS

$$\Delta X^M = X_A^M - X_B^M = (10, -5, -5, -5)$$

AND

i) $I = \Delta X^M \Delta X_M = 100 - (25 + 25 + 25) = 25 > 0$

ii) EVENTS THAT OCCUR SIMULTANEOUSLY ARE SPACELIKE ($I < 0$) SO NO FRAME EXISTS IN WHICH $\tilde{t}_A = \tilde{t}_B$.

iii) EVENTS THAT OCCUR AT THE SAME POINT ARE TIMELIKE ($I > 0$) SO A FRAME EXISTS IN WHICH $\tilde{x}_A = \tilde{x}_B$, $\tilde{y}_A = \tilde{y}_B$, AND $\tilde{z}_A = \tilde{z}_B$.

Prepared by:

Date:

PROBLEM 4

- i) ALL MASSLESS PARTICLES TRAVEL AT THE SPEED OF LIGHT
ii) FOR MASSLESS PARTICLES $E = pc = 0$

PROBLEM 5

CHARGE IS A LORENTZ INVARIANT (OR LORENTZ SCALAR)

MASS IS A LORENTZ INVARIANT (OR LORENTZ SCALAR)

LINEAR MOMENTUM IS THE SPACELIKE COMPONENT OF A FOUR VECTOR

ENERGY IS THE TIMELIKE COMPONENT OF A FOUR VECTOR

PROBLEM 6

THE MINKOWSKI VARIABLE S IS A LORENTZ INVARIANT. THUS,

- i) $S = 4 \text{ GeV}^2$ IN THE REST FRAME OF THE POSITRON.
ii) $S = 4 \text{ GeV}^2$ IN THE REST FRAME OF THE ELECTRON.