Problem 1 **COVARIANCE**

Consider the Galilean Transformation $x' = x - Vt, \quad t' = t$, and the Lorentz Transformation $x' = \Gamma(x - Vt), \quad t' = \Gamma(t - Vx), \quad \Gamma^2 \equiv 1/(1 - V^2)$, where we have used *c=1* units. These transformations connect two frames moving with V w.r.t. each other. Note that the motion of any mass *m* (rest mass) can be parameterized as *x(t), x'(t),* or *t'(t).*

1. Show that Newton's equations $dx/dt = u, \quad mdu/dt = F$ are covariant under GT. You may assume that *F* is a given constant. You may define *F'* in terms of *F* appropriately so as to accommodate covariance.

2. Show that Newton's equations are not covariant under LT, even if *F'* is appropriately defined in terms of *F* and *V*. (Find explicitly the equation in the unprimed frame if NE apply in the primed lab frame, or vice-versa.)

3. By contrast, show that Einstein's equations $dx/dt = u, \quad md[\gamma u]/dt = F, \quad \gamma^2 = 1/(1 - u^2)$ are covariant under LT.

["Covariance" is defined as "the equations look the same". i.e., both physicists agree on the type of all operations needed to describe motion under *F*.]