MTH 437 **HW #1** Winter 2004

1. **VECTORS IN MINKOWSKI SPACE**

Show that a timelike vector cannot be orthogonal to a null vector or to another timelike vector. Show that two null vectors are orthogonal if and only if they are parallel.

*Try to do this in 4 spacetime dimensions, rather than 2. A convenient notation is to view a 4-vector* $\mathbf{u}$ *as consisting of a timelike component* $u^t$ *and spacelike components making up an ordinary 3-vector* $\vec{\boldsymbol{u}}$*; one often writes*

$$\mathbf{u} = \begin{pmatrix} u^t \\ \vec{\boldsymbol{u}} \end{pmatrix}$$

2. **THE POLE AND BARN PARADOX**

Consider a 20 meter pole carried so fast in the direction of its length that it appears to be only 10 meters long in the laboratory frame of reference. Therefore, at some instant the pole can be entirely enclosed in a barn 10 meters long! However, from the frame of reference of the runner carrying the pole the barn appears to be contracted to half its length, i.e. 5 meters. How can a 20 meter pole fit into a 5 meter barn?

Provide a clear resolution of this "paradox". You may wish to consider what happens if the barn doors (one at each end) are closed ("at the same time") while the pole is "inside" the barn. Does this catch the pole inside the barn?

*"Resolve" means to (correctly!) explain what happens in* ***both*** *reference frames. This can be in words, using a spacetime diagram, via an explicit, numerical computation, or some combination of these.*

**Some further paradoxes can be found on the course home page.**
**You may choose to resolve one of those paradoxes instead of this one.**

(The following quote is from **Spacetime Physics** by Taylor & Wheeler.)
WHEELER'S FIRST MORAL PRINCIPLE: *Never make a calculation until you know the answer.*