

1. A train 0.5Km long, as measured by an observer on the train, travels at a speed of 100 Km/hr. Two lightning bolts strike the ends of the train simultaneously as determined by an observer on the ground. [5]
What is the time separation by an observer on the train?

S S' $\rightarrow 100 \text{ km/h}$

2. Prove that the line element, defined by $ds^2 = \eta_{\mu\nu} dx^\mu dx^\nu$ is invariant under a Lorentz transformation. Here $\eta_{\mu\nu}$ is the Minkowski metric. [5]

3. Use the equivalence principle to argue that the time period of a pendulum can not depend on the mass of the bob.

[3]

4. Consider a sphere of radius R . *a)* Write down the metric $g_{\mu\nu}$ (or the line element) on the sphere. *b)* Calculate the Christoffel symbols defined as [3+4]

$$\Gamma_{\mu\nu}^{\lambda} = \frac{g^{\alpha\lambda}}{2} \left(\frac{\partial g_{\nu\alpha}}{\partial x^{\mu}} + \frac{\partial g_{\mu\alpha}}{\partial x^{\nu}} - \frac{\partial g_{\nu\mu}}{\partial x^{\alpha}} \right). \quad (1)$$

Since this is a sphere...