1. The covariant derivative of a contravariant vector is

$$\nabla_\beta A^\alpha = \frac{\partial A^\alpha}{\partial x^\beta} + \Gamma^\alpha_{\beta\gamma} A^\gamma$$

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   (a) (3 pts.) Explain in words the meaning of the geodesic equation

   $$\nabla_u u = 0,$$

   where u is the 4-velocity. The geodesic equation is also called the equation of motion.

   (b) (3 pts.) Explain briefly Hartle's derivation of the covariant derivative of a covariant vector, equation 20.67.

2. In class on 22 March, we derived the Riemann curvature tensor $R^\sigma{}_{\gamma\alpha\beta}$.

   (a) (3 pts.) Outline the idea of the derivation.

   (b) (3 pts.) Show the steps in getting from the two covariant derivatives to the final result.

   (c) (3 pts.) The Riemann curvature tensor is a rank 4 tensor, also called a linear function with 3 vector inputs. What is the meaning of $R^\sigma{}_{\gamma\alpha\beta} S_\sigma A^\alpha B^\beta$?

3. In class we found that the Ricci tensor of a homogeneous and isotropic 3-dimensional space is $\tilde{R}_{ij} = -2r_0^{-2}\tilde{g}_{ij}$.

   (a) (3 pts.) Find the curvature scalar.

   (b) (3 pts.) Is $\tilde{R}_{ij} = -2r_0^{-2}\tilde{g}_{ij}$ true in 2 dimensions?

4. (5 pts.) Answer the questions posed in class on 27 March. Submit your answer on angel. The link is Lessons—Hwk7B. This and the next question are due by 2:40 on 27 Mar.

5. (5 pts.) Answer the questions posed in class on 29 March. Submit your answer on angel. The link is Lessons—Hwk7B.