PHYS/OCEA 4411/5411 "Atmospheric Dynamics 1"

Assignment #2
Due: Monday, 19 October 2009, at the beginning of class

1) A passenger walks with speed *v* to the front of a bus as it is rounding a corner with radius *R* at constant speed *U*. Assume the effects of the Earth's rotation can be neglected, and express all answers to the following questions in terms of *v*, *R* and *U*.
a) Determine the fictitious forces acting on the passenger according to a pedestrian on the sidewalk.
b) Determine the fictitious forces acting on the bus driver as observed by the passenger.
c) Determine the fictitious forces acting on the passenger as observed by herself.

2) Is it possible for there to be a geostationary orbit that is not above the equator? Explain your reasoning carefully.

3) Consider a horizontal pressure distribution on the spherical Earth described by

$$p = m\theta + b \quad ,$$

where θ is the latitude and *m* and *b* are constants.
a) Determine the gradient in standard spherical coordinates.
b) Determine the gradient in Cartesian coordinates.
c) Prove that the results of part a) and b) are equal.

4) a) Starting from

$$\vec{u} = \hat{r}\dot{r} + \hat{\theta}r\dot{\theta} + \hat{\phi}r\dot{\phi}\sin\theta \quad ,$$

derive the expression for acceleration in standard spherical coordinates,

$$\frac{d\vec{u}}{dt} = \hat{r}(\ddot{r} - r\dot{\phi}^2\sin^2\theta - r\dot{\theta}^2) + \hat{\theta}(r\ddot{\theta} + 2\dot{r}\dot{\theta} - r\dot{\phi}^2\sin\theta\cos\theta) + \hat{\phi}(r\ddot{\phi}\sin\theta + 2\dot{r}\dot{\phi}\sin\theta + 2r\dot{\theta}\dot{\phi}\cos\theta) \quad .$$

b) Apply the geophysical conventions to the acceleration equation above to obtain

$$\frac{d\vec{u}}{dt} = \hat{i}\frac{du}{dt} + \hat{j}\frac{dv}{dt} + \hat{k}\frac{dw}{dt} + \hat{i}(uw - uv\tan\phi)r^{-1} + \hat{j}(vw + u^2\tan\phi)r^{-1} - \hat{k}(u^2 + v^2)r^{-1} \quad .$$