PHYS-3202 Homework 9 Due 25 Nov 2020

This homework is due to `https://uwcloud.uwinnipeg.ca/s/LLijRqSDKdXgMDA` by 10:59PM on the due date. You may submit a Word doc/docx document (with an equation editor for mathematics) or a PDF (typed or black-and-white scanned).

1. **Deflection of Thrown Object** *based on Cline 12.1 and problems from elsewhere*

   Consider motion near the surface of the earth. The rotational frequency of the earth is ω, and θ is the colatitude.

   (a) From example 12.7 in the Cline textbook (page 305), a ball thrown straight upward to a maximum height h is deflected *west* a distance $(4\omega \sin\theta/3)\sqrt{8h^3/g}$ by the Coriolis effect. However, since the vertical velocity exactly reverses itself over the course of the ball's flight, the Coriolis force on the way down is exactly opposite the Coriolis force on the way up. Why is the ball deflected horizontally at all?

   (b) The case of the ball thrown upward contrasts to a ball dropped from a height h, which deflects to the *east* by $(\omega \sin\theta/3)\sqrt{8h^3/g}$ (see example 12.6 or the class lecture notes). Why does the Coriolis force deflect the thrown ball in the opposite direction than the dropped ball? And why is the deflection four times greater in magnitude for the thrown ball?

   (c) Suppose I throw the ball at an angle α from the vertical toward the east. Is the ball deflected north or south? Does it land before or after I expect it would ignoring the Coriolis force? *Hint*: start by writing the Coriolis force to lowest order in ω as in class.

   (d) Again, I throw the ball at an angle α from the vertical toward the east with initial speed v_0. Show that the Coriolis force deflects the trajectory $(4\omega v_0^3/g^2)\cos\theta \sin^2\alpha \cos\alpha$ south compared to where it would land without the Coriolis effect (in addition to the westward deflection we discussed in the first two parts of the problem).

2. **Hyperloop**

   The hyperloop is a proposed high-speed transit system in which a pod travels through a sealed tube at approximately 1200 km/hr. One initially proposed route would run from Los Angeles to San Francisco, which you can approximate as running due north along a longitude line on the surface of the earth. Treat the earth as a perfect sphere.

   (a) Is the magnitude of the Coriolis force on the hyperloop pod larger at the Los Angeles (south) or San Francisco (north) end of the hyperloop? Explain briefly.

   (b) Is the magnitude of the Coriolis force on the hyperloop pod larger or smaller than magnitude of the centripetal force required to hold the pod to the surface of the earth? Explain briefly. Los Angeles has latitude of 34 degrees.