SMS 303: Homework I. Coriolis, Inertial Oscillation and Baseball

From Newton's 2nd law we know that:

Mass*acceleration=Force.

It is often convenient to divide both sides by mass:

Acceleration=Force/Mass.

Now, consider an object on a rotating platform that rotates at angular velocity Ω (= 2 π radians / period, where the period is the time it takes for one full rotation). In order to account for the rotation of the platform an apparent force known as the Coriolis force is added to the equations. In two dimensions those are:

$du/dt=F_x/Mass+2\ \Omega v$

$dv/dt=F_y\ /Mass-2\ \Omega u$

where (u,v)=(dx/dt, dy/dt), are the velocities in the x and y directions respectively. Here we assume x is eastward and y is northward.

Let's assume that we give a kick to the object in the direction y at time zero and observe how it moves without applying any extra force. Initial condition $v(t=0)=V_0$. Let us also denote $f=2\Omega$ (On the Earth and latitude ϕ, f is the Coriolis parameter and $f = 4\pi \sin\phi / 24\ hr^{-1}$).

$du/dt=fv$

$dv/dt=-fu$

Solution (please check):

$u= -V_0\cos(ft),\quad v= V_0\sin(ft)$

Homework (be careful regarding units).

1. Solve for the position (x, y) as function of time, assuming x(t=0)=y(t=0)=0 (remember, u=dx/dt, v=dy/dt).

2. Plot the position of the object as function of time for 24 hours (every 1hr) assuming a latitude of 30°N. What is the shape of the trajectory? How long does it take for the object to come back to its initial position?

3. Now, assume that we are dealing with baseball and Fenway park (~42°N). The speed of the ball leaving the bat is 40m/s. Neglecting friction, what would be the Coriolis deflection of the ball be after 2 seconds?

Further reading:

http://en.wikipedia.org/wiki/Coriolis_effect

Durran, D. R., 1993: *Is the Coriolis force really responsible for the inertial oscillation?*, Bull. Amer. Meteor. Soc., 74, 2179–2184; Corrigenda. Bulletin of the American Meteorological Society, 75, 261 (http://www.atmos.washington.edu/~durrand/pdfs/Coriolis_BAMS.pdf)

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