**Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Exam#1**

**Applied Numerical Weather Prediction Due: 3:00 pm, 3 March 2022**

***NOTE: All work is to be completed individually, without consulting any other person.***

**Project#21 {20 total points}**

**(21.1)** Create a program that computes the zonal wind component (*u*) of the following function:



where ***A***, ***k1***, and ***ω1*** are equal to 20 m s-1, π /(1x106 m), and 3.14x10-5 s-1, respectively, and ***B***, ***k2***, and ***ω2*** are equal to 10 m s-1, 2π /(1x106 m), and 6.28x10-5 s-1, respectively, as ***x*** varies from 2000 km to +2000 km using 1001 and 91 grid points to make the appropriate finite difference [FD] calculations of the zonal wind component and horizontal divergence [*∂u*(*x,t*)/*∂x*] at *t* = 86,400 s. To receive full credit, show how you obtain your analytic solution for *∂u*(*x,t*)/*∂x.* Create one plot over the domain as ***x*** varies from 2000 km to +2000 km showing the zonal wind component for 1001 (curve 1) and 91 (curve 2) grid points.

**(21.2)** Create a second plot of normalized horizontal divergence [ *∂u*(*x,t*)/*∂x*] at *t* = 86,400 s using **forward-in-space differencing** over the +/****2000 km domain for a model having 91 grid points (curve 1), along with the analytic normalized horizontal divergence (curve 2). Normalize the original FD and analytic horizontal divergence estimates by dividing by a constant equal to 1.106x10-4 s-1. Normalizing the horizontal divergence allows one to plot the y-axis from ****1.0 to +1.0. Create a third plot of normalized horizontal divergence [ *∂u*(*x,t*)/*∂x*] at *t* = 86,400 s using **forward-in-space differencing** over the +/****2000 km domain for a model having 1001 grid points (curve 1), and the analytic normalized horizontal divergence (curve 2). Create a fourth (and final) plot of the difference of the 1001 grid point and analytic normalized horizontal divergence (curve 1; FD **** analytic).

[q21.2.1] Does examination of the first plot (zonal wind curves of 91 and 1001 grid point models) show any obvious differences in zonal wind. Does the raw data show a systematic difference in the peaks of the zonal wind across the model domain?

[q21.2.2] How does the normalized horizontal divergence of the 91 grid point model in the second plot compare to the analytic horizontal divergence? Speak both to positioning differences of divergence maxima/ minima and to systematic differences (bias) in the maxima/ minima of the normalized horizontal divergence.

**{questions continue on the backside of the page}**

[q21.2.3] Does examination of the third plot (normalized horizontal divergence of the FD 1001 grid point and analytic solution curves) show any obvious differences in horizontal divergence? Does the fourth plot (differences in 1001 FD and analytic normalized horizontal divergence) show a bias of the FD solution toward overdoing horizontal divergence or convergence over the model domain?

[q21.2.4] Write down the horizontal resolution (Δx) of the 1001 and 91 grid point domains

Δx (1001 grid points) =\_\_\_\_\_\_\_\_\_\_[km]

Δx ( 91 grid points) =\_\_\_\_\_\_\_\_\_\_[km]

Recalling the relationship between surface horizontal divergence and vertical motion just above the ground (via the anelastic continuity equation, Activity #2) and assuming ascending air parcels produce clouds and precipitation, what might be some errors (positioning and/or strength) of the FD horizontal divergence using the 91 [q21.2.2] and the 1001 [q21.2.3] compared to the “true” (analytic) solution?