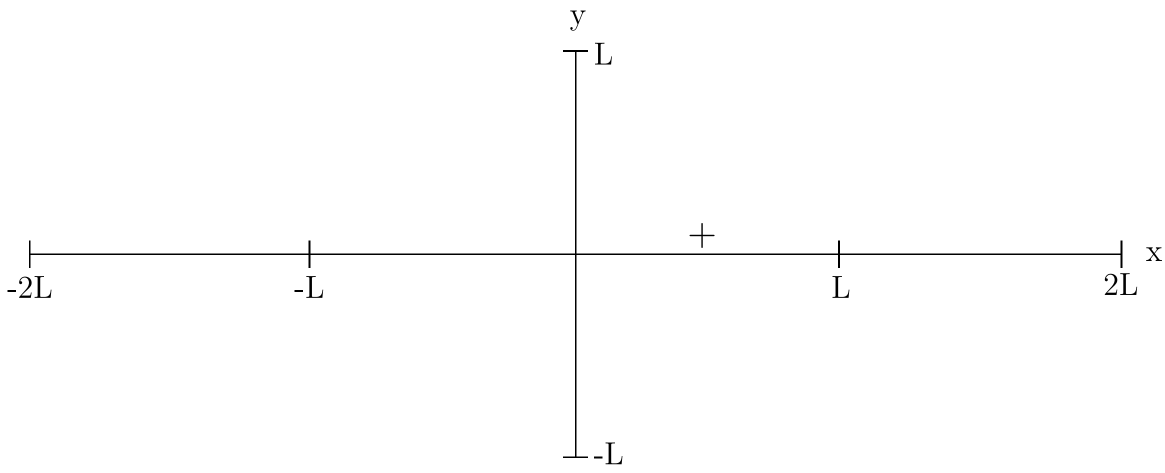
NAME:

ATMS 441/503 Worsheet on Streamfunctions, 3 Dec. 2010. Hand in before leaving.

1. Begin by exercising your graphing skills. By hand, graph both equations on the axes below

$$y = \frac{L}{2}\sin\left(\frac{\pi x}{L}\right) \quad \text{and} \quad x = \frac{L}{2}\cos\left(\frac{\pi y}{2L}\right)$$

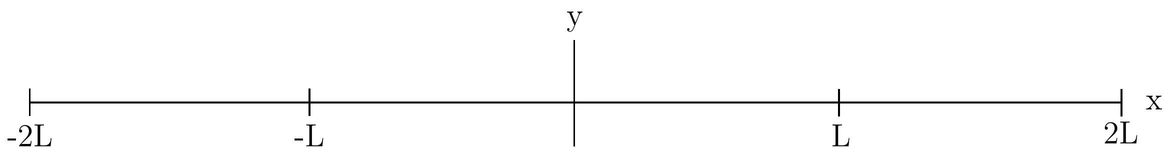
Hint, for the second one, rotate the paper by 90°.



2. Now take the product of the above trig functions and consider it a horizontal geopotential field:

$$\Phi(x, y) = \Phi' \sin\left(\frac{\pi x}{L}\right)\cos\left(\frac{\pi y}{2L}\right)$$

Place pluse and minus signs at the local maxima and minima on the x-axis for Φ.



3. Try to visualize $\Phi(x, y)$

4. C. B. modified some scripts from the CD that came with the textbook for chapter 3. You can download her improved versions from a link on Nov 19 on the class schedule if you want copies. see http://www.atmos.washington.edu/2008Q4/441/schedule.html

5. Run the matlab script **trajectory_1** first with defaults settings by hitting return 3-times without typing anything to plot Φ from part 2 above. What do the solid and dashed contours indicate?

6. Make Φ move to the right with *phase speed c* by rerunning **trajectory_1** (type ↑ to cycle through the last things you typed in matlab)

$$\Phi(x, y, t) = \Phi' \sin\left(\frac{\pi(x - ct)}{L}\right)\cos\left(\frac{\pi y}{2L}\right)$$

Make some notes about your observations:

7. Next consider the geopotential field

$$\Phi(x,y) = \Phi_0 - f\bar{U}l^{-1}\sin(ly)$$

with $l = \pi/(2L)$ and $\Phi_0/g = 5500$ m. Sketch the approximate contour field for $\Phi(x,y)$ for the domain shown in par 1, with $f\bar{U}l^{-1}/g \sim 500$ m. What is the physical interpretation of $\bar{U}$? What does this Φ represent?

8. Crudely sketch the sum of the $\Phi(x,y)$'s in parts 2 and 6 assuming $\Phi' \sim f\bar{U}l^{-1}$.

9. Now make the wave move eastward in time:

$$\Phi(x,y,t) = \Phi_0 - f\bar{U}l^{-1}\sin(ly) + \Phi'\sin[k(x-ct)]\cos(ly)$$

With $\Phi_0/G = 5500$ M, $l = \pi/(2L)$, and $k = \pi/L$

a. Compute the geostrophic wind components for this Φ by taking the following derivatives:

$$u_g = -f^{-1}\frac{\partial\Phi}{\partial y} =$$

$$v_g = f^{-1}\frac{\partial\Phi}{\partial x} =$$

b. Run the matlab script **trajectory_2** to see some snapshots of the moving wave.

Contours of Φ are everywhere parallel to the geostrophic motion. "Streamlines" are everywhere parallel to the actual wind. Hence Φ is like a streamline but for the geostrophic wind.

c. Make some notes about your observations, focusing on the shape of Φ. For example, what variables make a strong westerly wind with a minimal wave? What values of the variables make deep cyclones and anticyclones. What eliminates any cutoff lows/highs (ie closed contours)?

9. For more, run **trajectory_3** where Φ is modified to make trough and ridge lines tilt and $\Phi_0 = 0$. The script animates the motion of a cluster of parcels initially placed in a small circle. You can repeat you animation by typing *movie(M)*.