metr2413 - Lab 10 Solutions
University of Oklahoma - Spring 2004

First compute some of the used numbers and rates.

$$dx = -260miles = -418600m$$

$$dy = 60miles = 96600m$$

$$\frac{dP}{dx} = \frac{P_{amarillo} - P_{norman}}{-418600m} = \frac{-1000Pa}{-418600mb}$$

$$\frac{dP}{dy} = 0$$

$$R = \sqrt{(dx)^2 + (dy)^2} = 429600m$$

$$f = 2\Omega sin\Phi = 2(7.292 \times 10^{-5}s^{-1})sin(35) = 8.36 \times 10^{-5}s^{-1}$$

$$\vec{V} = 30knots = 15.43ms^{-1}$$

$$U = 0knots = 0ms^{-1}$$

$$V = 30knots = 15.43ms^{-1}$$

Pressure Gradient Force *This x-component of the PGF is one that most calculated correctly.*

$$F_{PGF_x} = -\frac{1}{\rho}\frac{dP}{dx} = -\frac{1}{1.22kgm^{-3}}\frac{-1000Pa}{-418600mb} = -1.96 \times 10^{-3}ms^{-2}$$

The y-component was a source of some trouble. From the given map, it appears that there is no y-direction PGF, so $\frac{dp}{dy} = 0$. This answer was acceptable. It was also acceptable to compute the PGF_y by carefully measuring the pressure gradient in the y-direction from hand-analyzing the chart, which would give a value of about $4.24 \times 10^{-4}ms^{-2}$. If you used the distance from the center of the low to KOUN, that was incorrect.

$$F_{PGF_y} = -\frac{1}{\rho}\frac{dP}{dy} = 0$$

Gravitational Force *There was some confusion here. The given equation is read as "the x-component of the gravitational force is", but the actual answers for both x-direction and y-direction is* $0ms^{-2}$. *If you put* $-9.8ms^{-2}$ *you were not penalized, but the answer in incorrect.*

Coriolis Force

$$F_{cor_x} = fV = (8.36 \times 10^{-5}s^{-1})(15.43ms^{-1}) = 1.29 \times 10^{-3}ms^{-2}$$

$$F_{cor_y} = fU = (8.36 \times 10^{-5}s^{-1})(0ms^{-1}) = 0ms^{-2}$$

Centrifugal Force

$$F_{cent_x} = s\frac{V|\vec{V}|}{R} = \frac{(15.43ms^{-1})^2}{429600m} = 5.54 \times 10^{-4}ms^{-2}$$

$$F_{cent_y} = s\frac{U|\vec{V}|}{R} = \frac{0ms^{-1}(15.43ms^{-1})}{429600m} = 0ms^{-2}$$

Friction Force

$$M = \vec{V} = 15.43ms^{-1}$$

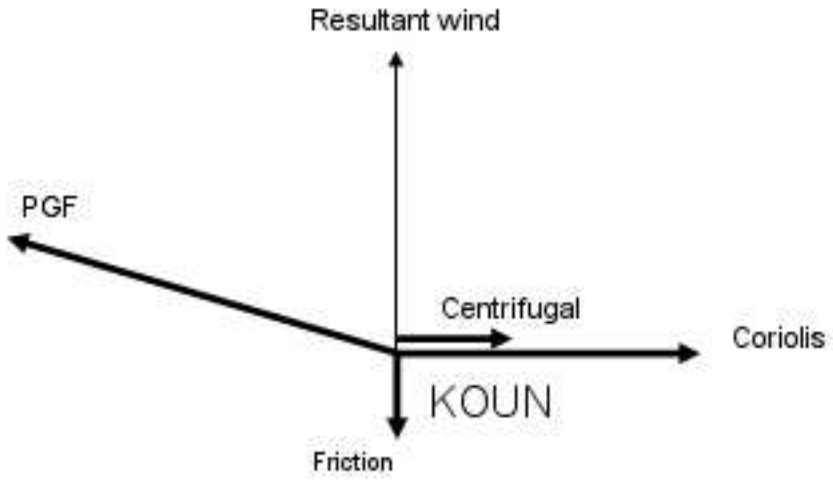
$$F_{fric_x} = -C_dM\frac{U}{z} = -()(15.43ms^{-1})\frac{0ms^{-1}}{1000m} = 0ms^{-2}$$

$$F_{fric_y} = -C_dM\frac{V}{z} = -()(15.43ms^{-1})\frac{15.43ms^{-1}}{1000m} = -5.24 \times 10^{-4}ms^{-2}$$

Force	x-component	y-component
PGF	-1.96×10^{-3}	0
Gravitional	0	0
Coriolis	1.29×10^{-3}	0
Centrifugal	5.54×10^{-4}	0
Friction	0	-5.24×10^{-4}
Total	-1.16×10^{-4}	-5.24×10^{-4}

Vector Illustration *Another confusing part of this assignment involved the PGF vector. From the above analysis, there is no y-component of the PGF. But from the map, the PGF vector would be directed towards the center of the low, to the northeast. There was no penalty for not drawing the PGF vector towards the center of the low. The fact that the vector is directed to the northeast also shows that there is a y-component to the PGF, which can be computed manually*

from the map, though it was not required.



Dominant Forces *The PGF and Coriolis force are an order of magnatude greater than any other forces:* 10^{-3} *versus* 10^{-4}*, so they are the two dominant forces for this problem.*

Neglected Forces *In addition to gravity, which plays no role in horizontal motion, the centrifugal force and frictional force are on the order of* 10^{-4}*, and when compared to the PGF and Coriolis force (*10^{-3}*), they can safely be neglected.*