PSET 8

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A. We know the Rossby number is given by $Ro = \frac{U}{fL}$, where we can approximate $U = 0.1$ m/s, the speed of the water draining out of the bucket, and for simplicity, also assume $L = 0.1$ m. Thus, we can estimate:

$$Ro = \frac{U}{fL}$$
$$Ro = \frac{0.1 \text{ m/s}}{2 \times 7.3 \times 10^{-5} \text{ s}^{-1} \times \sin(0.1) \times 0.1 \text{ m}}$$
$$Ro \approx \frac{10^{-1}}{2 \times 2\pi \times 10^{-5} \times 10^{-3} \times 10^{-1}}$$
$$Ro \approx \frac{1}{10 \times 10^{-5} \times 10^{-3}} \approx 10^{7} >> 1$$

Thus, we can conclude that the Coriolis force is negligible in this case.

B. In order for the Coriolis force to be negligible, we need $Ro << 1$. Thus:

$$Ro = \frac{U}{fL} << 1$$
$$U << fL$$
$$U << 2 \times 7.3 \times 10^{-5} \text{ s}^{-1} \times \sin(0.1) \times 0.1 \text{ m}$$
$$U << 10 \times 10^{-5} \times 10^{-3} \times 10^{-1} \text{ m/s}$$
$$U << 10^{-8} \text{ m/s}$$

C. No, it wouldn't matter. Although at the North Pole, the Coriolis force is at its strongest, the minute amount of water and drainage speed would be still be negligible along with the Coriolis force, and Ro would still be $>> 1$.

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A. The air rotated clockwise in Cyclone Yasi.

B. From the first graph, we can see that Cyclone Yasi hit Australia at around 20°S. We are given that $\rho = 1$ kg m^{-3}, and that a degree of latitude measures 111 km. From the second graph, we see that a degree of latitude measures a $\Delta p = 1004 - 1000 = 4$ hPa, thus, assuming geostrophic balance, the wind speed is:

$$\Delta p = V \rho f \Delta x$$
$$4 \text{ hPa} = V \times 1 \text{ kg m}^{-3} \times 2 \times 7.3 \times 10^{-5} \text{ s}^{-1} \times \sin(20°) \times 111 \text{ km}$$
$$4 \text{ hPa} \approx V \times \pi \text{ kg m}^{-2} \text{ s}^{-1}$$
$$V = \frac{4 \text{ hPa}}{5.54 \text{ kg m}^{-2} \text{ s}^{-1}}$$
$$4 \text{ hPa} = 400 \frac{\text{N}}{\text{m}^2} = 400 \frac{\text{kg}}{\text{ms}^2}$$
$$V \approx \frac{400\text{kg}}{\text{ms}^2} \cdot \frac{1\text{m}^2\text{s}^1}{\pi\text{kg}} \approx 100 \text{ m/s}$$

Compared to the speed of sound at sea level (340 m/s), this is a reasonable answer for the wind speed of a cyclone.

C. Balancing the Coriolis and centrifugal forces against the pressure gradient force, and assuming $r = 111$ km, we have:

$$fV + \frac{V^2}{r} = \frac{1}{\rho} \frac{\partial p}{\partial x}$$
$$2 \times 7.3 \times 10^{-5} \text{ s}^{-1} \times \sin(20°) \times V + \frac{V^2}{111 \text{ km}} = \frac{1}{1 \text{ kg m}^{-3}} \frac{4 \text{ hPa}}{111 \text{ km}}$$
$$\pi \times 10^{-5} \text{ s}^{-1} \times V + \frac{V^2}{10^5 \text{ m}} = \frac{400 \text{ m}}{10^5 \text{ s}^2}$$
$$\pi \text{ ms}^{-1} \times V + V^2 = 400 \frac{\text{m}^2}{\text{s}^2}$$
$$V^2 + \pi V - 400 = 0$$
$$V = \frac{-\pi \pm \sqrt{\pi^2 + 4 \times 400}}{2}$$
$$V \approx \frac{-\pi + \sqrt{\pi^2 \times 10^2}}{2}$$
$$V \approx \frac{-\pi + \pi \times 10}{2} \approx \pi^3/2 \approx \pi^2 \approx 10 \text{ m/s}$$

This value considerably changes depending on our estimation of r.