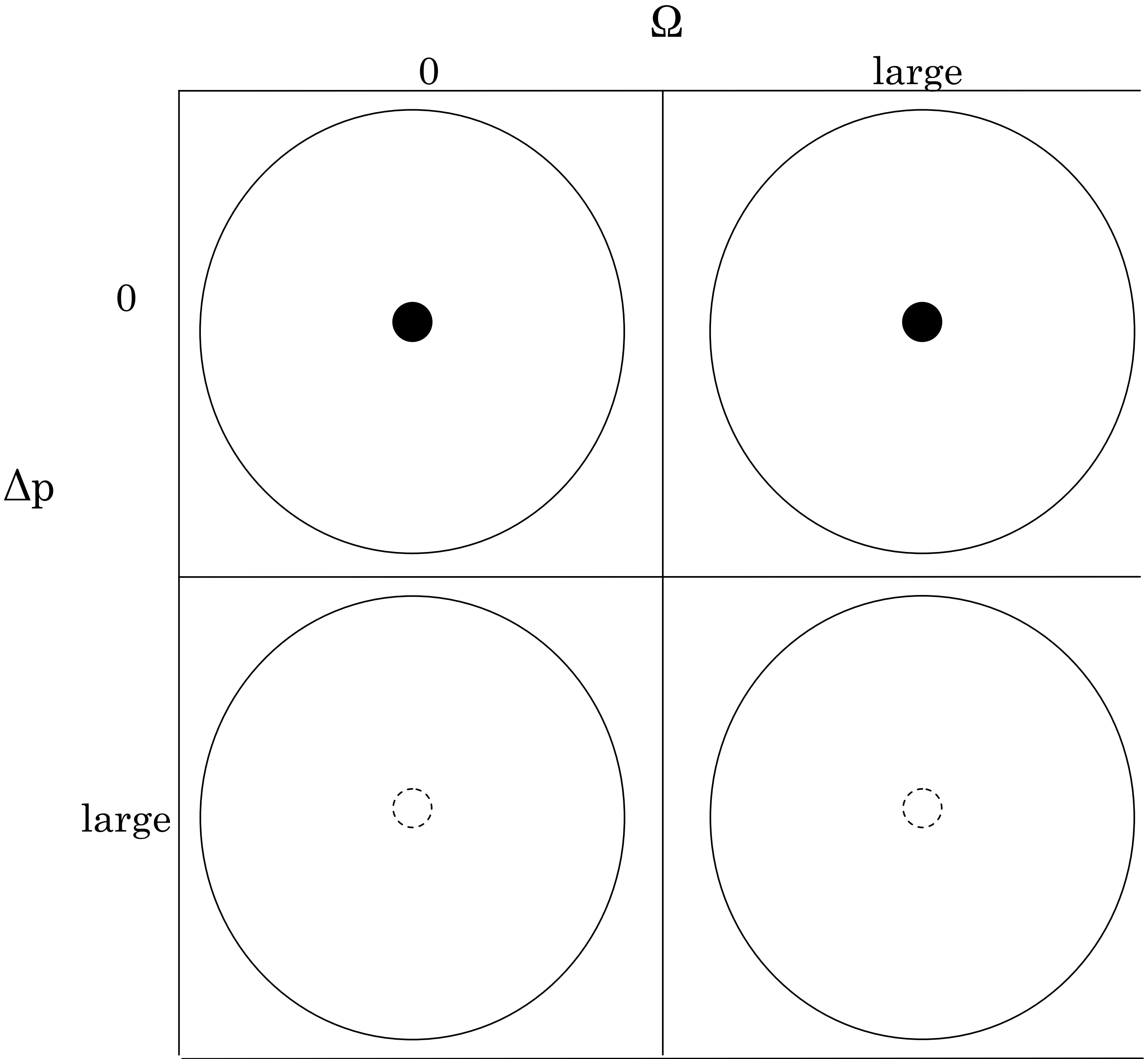
Balanced Motion

Exercise sheet accompanying the balanced motion (radial inflow) experiment. The experiment is described here: http://paoc.mit.edu/labguide/balmo_exp.html. The rotation rate of the tank is Ω. The radial pressure difference is Δp. We consider a matrix of four experiments in which Ω and Δp vary.



Your predictions…Imagine a paper dot being released in the water, sketch what happens to the paper dot in each of the four experiments. Feel free to add comments in the margin

Experiment 4: Ω large and Δp large

This experiment exhibits a number of important principles of rotating fluid dynamics including conservation of angular momentum and balance of forces. Here we will focus on the role of rotation in influencing the motion. Let's define a non-dimensional number, R_o, as the ratio of two timescales, the so called Rossby number,

$$R_o = \frac{\tau_{\tan k}}{\tau_{motion}} = \frac{\tau_{\tan k}}{\tau_{particle}}, \tag{1}$$

where $\tau_{\tan k}$ is the rotation period at which the cylinder/tank is spun and $\tau_{motion} = \tau_{particle}$ is the period of the circular motion set up in the tank, which can be measured by tracking the paper dot. Let's track 3 particles, one released toward the hole in the center, one at mid-radius and one at the outer wall. We will compute the associated Rossby numbers for each.

$\tau_{\tan k} =$ ________________ seconds

	Particle type	$\tau_{particle}$	R_o
1	Outer		
2	Middle		
3	Inner		

Where is the Rossby number large? Small?

If R_o << 1, then the effect of the system rotation will be very pronounced. In this limit, the pressure gradient force is balanced by the Coriolis forces. This is typical of the large-scale motion in the atmosphere.

If R_o >> 1, then the effect of the system rotation will be negligible. In this limit, the pressure gradient force is balanced by the centrifugal force. This is typical of hurricane eyes or tornadoes.

If R_o ~ 1, the horizontal pressure gradient force is balanced by the Coriolis force and centrifugal force together. This is typical of hurricane flows away from the eye.

For more on the theory see: http://paoc.mit.edu/labguide/balmo_theory.html.