1. **(6)** In the eddy current dynamometer setup, a clever device is used to directly measure torque. As seen in the sketch to the right, mass *m* is attached to a wheel of radius *R*, and is lifted up as torque *T*applied is applied (counterclockwise) to the wheel. Gravity provides a constant downward force , but the moment arm (torque arm) *r* increases as the weight moves up in elevation, causing an increase in the counteracting (clockwise) torque *T*counteracting. The wheel is stationary when , which is read directly on the torque scale built into the instrument. **a)** Derive an expression for torque *T* as a function of weight *W*, radius *R*, and angular displacement *θ*, showing all your algebra for full credit. **b)** Does torque increase *linearly* or *nonlinearly* with angular displacement *θ*? Explain.
2. **(7)** **a)** At a temperature of 22oC and a pressure of 98.5 kPa, calculate the air density using the ideal gas law. **b)** If the mass flow rate of the air is 0.025 kg/s, calculate the volume flow rate of the air in m3/s. Show all your work in the space below. **c)** Repeat for an air temperature of 50oC.
3. **(7)** A Pitot-static probe is used to measure air velocity at a temperature of 22oC and a pressure of 98.5 kPa. The pressure difference is 1.00 inches of water column. (Use *ρ*water = 1000 kg/m3 and *g* = 9.807 m/s2.) **a)** Calculate the air speed in m/s. Show all your work in the space below. **b)** Repeat for an air temperature of 50oC.