17 November 2023

Mechanical, Automotive and Materials Engineering
Fluid Mechanics I
MECH-3233-F23

# Assignment Problems Set #9

**Problem 1 (6 points):** The volume flow $Q$ through an orifice plate is a function of pipe diameter $D$, pressure drop $\Delta p$ across the orifice, fluid density $\rho$ and viscosity $\mu$, and orifice diameter $d$. Using $D$, $\rho$, and $\Delta p$ as repeating variables, express this relationship in dimensionless form.

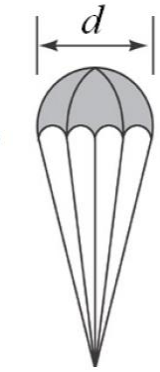
**Problem 2 (6 points):** The volume flow $Q$ over a certain dam is a function of dam width $b$, gravity $g$, and the upstream water depth $H$ above the dam crest. It is known that $Q$ is proportional to $b$ ($Q \propto b$). If $b$ = 120 ft and $H$ = 15 in, the flow rate is 600 $ft^3/s$. What will be the flow rate if $H$ = 3 ft?

**Problem 3:** The power $P$ generated by a certain windmill design depends upon its diameter $D$, the air density $\rho$, the wind velocity $V$, the rotation rate $\Omega$, and the number of blades $n$. Use (***D, ρ, V)*** as repeating variables.

(a) Use the dimensional analysis and find suitable pi parameters for this problem. (**2 points**)

(b) A model windmill, of diameter 50 cm, develops 2.7 kW at sea level when $V$ = 40 m/s and when rotating at 4800 rev/min What power will be developed by a geometrically and dynamically similar prototype, of diameter 5 m, in winds of 12 m/s at 2000 m standard altitude ($\rho_{air}$ = 1.0067 $kg/m^3$)? (**2 points**)

(c) What is the appropriate rotation rate of the prototype? Take the density of air in see level to be $\rho_{air}$ = 1.2255 $kg/m^3$. (**2 points**)




**Problem 4:** Flow characteristics for a 30-ft-diameter prototype parachute are to be determined by tests of a 1-ft-diameter model parachute in a water tunnel. Some data collected with the model parachute indicate a drag of 17 lb when the water velocity is 4 ft/s.

(a) Use the dimensional analysis and find a suitable pi parameter for this problem. (**2 points**)

(b) Use the model data to predict the drag on the prototype parachute falling through the air at 10 ft/s. Assume the drag to be a function of the velocity, $V$, the fluid density, $\rho$, and the parachute diameter, $d$. ($\rho_{water}$ = 1.94 $slugs/ft^3$ and $\rho_{air} = 2.38 \times 10^{-3}$ $slugs/ft^3$) (**2 points**)