NAME: _________________________ STUDENT #___________

**AESB2320, 2016-17**

**Part 1 Examination - 14 March**

**<u>Turn in this exam with your answer sheet.</u>**

Write your solutions *on your answer sheet*, not here. In all cases ***show your work***.

**To avoid any possible confusion,**

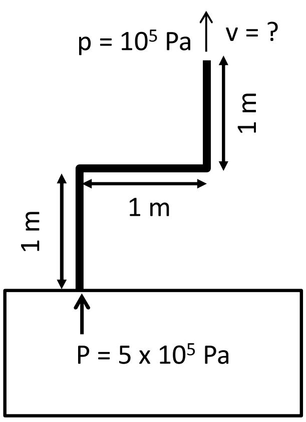
**state the equation numbers and figure numbers of equations and figures you use**

***along with the text you are using (BSL2 or BSLK)***.

Beware of unnecessary information in the problem statement.

1. A Newtonian fluid flows through a tube of radius R. The potential gradient driving the flow is $\Delta\mathcal{P}/L$. The wall is fixed in place (not moving). Viscosity is not constant for this fluid, however, but varies with position according to
   $\mu = 1/[A + B\,(r/R)]$
   where A and B are constants greater than zero. Solve for the velocity of the fluid in the tube $v_z$ as a function of r. You do not need to repeat any part of a derivation in the text that applies directly here, but if you use an equation in the text give the equation number and edition of the text (BSL1, BSL2, BSLK) that you are using.
   (25 points)

2. A laboratory flow apparatus contains water ($\rho$ = 1000 kg/m$^3$, $\mu$ = 0.001 Pa s) at a pressure of 5 x $10^5$ Pa. A tube of diameter 3 mm exits the top of the apparatus and follows a path upward as shown, including two sharp (not rounded) 90° elbows. The tube breaks at the end and water shoots out the top. The roughness factor in the tube (k/D) is 0.004. The pressure at the tube outlet is atmospheric pressure, i.e. $10^5$ Pa.
   a. Derive a formula for the velocity at which water leaves the tube.
   b. Solve this equation for the velocity.
   (40 points)




3. A published correlation states that "very well sorted" (i.e., a uniform packing of) coarse sand grains has a porosity of about 0.42 and a permeability of about 3 x $10^{-10}$ m$^2$. A similar packing of very-fine sand grains have a porosity of about 0.42 and a permeability of about 6 x $10^{-12}$ m$^2$. Estimate the diameters of "coarse" and "very fine" sand grains implied by these values.
   (15 points)

4. An engineer pumps a liquid through a slit of width W, gap width 2B, and length L at a volumetric flow rate $Q_1$ and measures a pressure difference between inlet and outlet $\Delta p_1$. (Note this is pressure difference, not flow-potential difference.) She then applies a pressure difference ($2\Delta p_1$), and the flow rate is less than ($2Q_1$). Which of the following are possible explanations for this observation? There may be more than one correct answer; indicate all correct answers ***on your answer sheet***. The answer could be one, more than one, or none of the following.
   a. It is a Newtonian fluid in laminar flow. The slit is horizontal.
   b. It is a Newtonian fluid in highly turbulent flow. The slit is horizontal.
   c. It is a Bingham plastic in laminar flow. The slit is horizontal.
   d. It is a shear-thinning power-law fluid in laminar flow. The slit is horizontal.
   e. It is a shear-thickening power-law fluid in laminar flow. The slit is horizontal.
   f. It is a Newtonian fluid in laminar flow. The slit is vertical, with the outlet higher than the inlet.
   g. It is a Newtonian fluid in laminar flow. The slit is vertical, with the outlet lower than the inlet.
   h. The slit is horizontal. The gap width (2B) of the slit has changed during the test: specifically, the slit may stretched at the higher pressure difference, with (2B) larger in the second test than the first test. (This is a problem in some experiments.)

   (20 points)