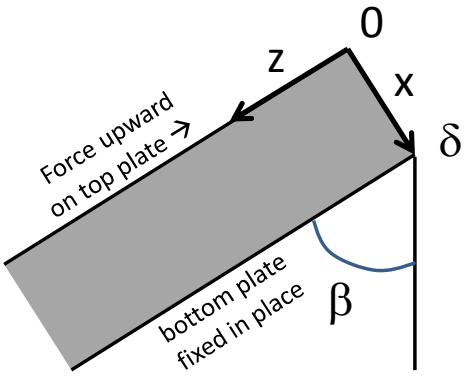
NAME: _____ STUDENT #_____

AESB2320, 2017-18
Part 1 Examination - 13 March

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 is held between two plates held at an angle to the vertical β as shown below. The bottom plate is held fixed in place. The top plate is pulled upwards with a force such that the shear stress on the top surface has a fixed value τ_{xz}*. (Note that τ_{xz}* < 0 because the force is in the negative-z direction.) The velocity of the top plate is not specified, just the force applied to it. Gravity pulls the fluid between the plates downward, but there is no applied pressure gradient in the slit.
   a. Derive a formula for the shear stress in the fluid as a function of x.
   b. Derive a formula for the velocity of the fluid $v_z(x)$ between the plates.
   c. If the top plate is pulled upwards with sufficient force, *all* the fluid in the gap moves upward. What is the minimum magnitude of the shear stress τ_{xz}* for which this happens? Briefly justify your answer. (10 points for this part; don't spend too long on this if you don't get it.)



You do not need to repeat any part of a derivation in the text that applies directly here. If you use an equation in the text give the equation number and edition of the text (BSL1, BSL2, BSLK) that you are using.
(35 points)

2. There is concern about gas flowing into a mine through fractures in the mine wall. Assume a fracture is a smooth, horizontal, rectangular slit, and assume the gas is incompressible, with constant density ρ and viscosity μ. The potential gradient driving the flow is fixed at $\Delta\mathcal{P}/L$. An engineer estimates the gap width 2B and calculates a volumetric flow rate Q through the fracture. Then the engineer decides the fracture gap width 2B is actually twice his original estimate. How much greater would the calculated volumetric flow rate Q (at the same values of W and $\Delta\mathcal{P}/L$) be if the flow is
   a. laminar?
   b. highly turbulent (very large Re)? Assume for simplicity that the roughness factor does not change for the wider fracture.

   (25 points)

3. A pump takes water (density 1000 kg/m^3 and viscosity μ 0.001 Pa s) from a large bucket and pumps it up through pipes and out the end of a pipe, as shown at right, at a volumetric flow rate of 0.0001 m^3/s. The pressure at the top of the bucket and at the outlet of the pipe are both atmospheric. All the tubing is 1 cm wide. The tubing can be considered very smooth. All the elbows are sharp, not rounded. What is the total rate of work required of the pump to maintain this flow rate?

   (40 points)