

Grading guidelines Quiz 2, Problem 2

a) 10 points

- 3 points. Water leaving the spout will experience the force of gravity pulling it down  $\rightarrow$  the water responds by accelerating
- 3 points. Although the velocity increases, the mass flow rate is constant (problem statement says so)
- 4 points. Since the mass flow rate is constant, and water is incompressible, then as the water velocity increases, the cross sectional area must decrease so that the product of velocity and area is constant as required by mass conservation  $\rightarrow$  the diameter decreases

b) 20 points

- 5 points. Assume frictionless, steady flow along a streamline  $\rightarrow$  Bernoulli's equation applies. Apply it from the faucet outlet at "0" and point "1" at  $x$ .
- 5 points.  $P_1 = P_0 = P_{atm}$  since the flow is unbounded, and surface tension is negligible
- 5 points.  $V_1^2 = V_0^2 + 2g(Z_0 - Z_1)$
- 5 points.  $(Z_0 - Z_1) = x$

c) 10 points

- 3 points. Mass is conserved, flow is steady  $\rightarrow \dot{m}_1 = \dot{m}_0$
- 3 points. Incompressible flow  $\rightarrow A_1 V_1 = A_0 V_0$
- 2 points.  $A = \frac{\pi}{4} d^2$
- $V$  was found in (b)
- 2 points. Final expression

d) 10 points

- 6 points. Force required to hold plate is proportional to the change in momentum of the water jet striking it.  $F \propto \dot{m}V$
- 4 points.  $\dot{m}$  is constant while  $V$  increases with  $x \rightarrow F$  increases with  $x$