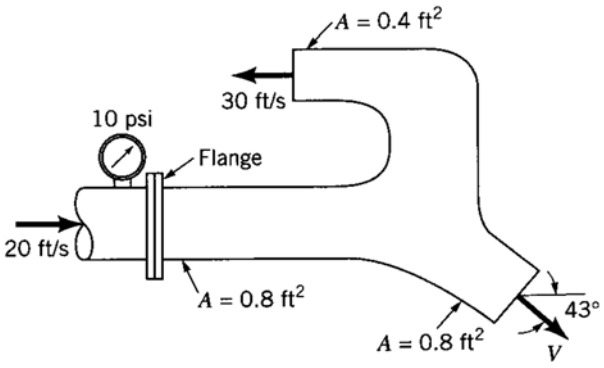
CE 251, Fluid Mechanics, Exam 2, Fall 2016 **Name:**
Bernoulli, Momentum, Energy

If you would like to receive partial credit, show all your work and state assumptions.
If you believe you are missing something, or you need clarification on a problem, *please ask!*
If you cannot finish in the allotted time, write down how you would complete the problem(s).

1. (15 pts) A venturi meter measures the flow rate entering the Easton water treatment plant. This device consists of a smooth constriction in a horizontal pipe, with piezometer connections just upstream of the construction (D = 30 inches) and within the constriction (D = 24 inches). The piezometers are connected together at a differential pressure transducer. If the pressure head difference between the two points is 1 inch of water, what is the flow rate? Give you answer in **million gallons per day (MGD)** – standard flow units for treatment plants.

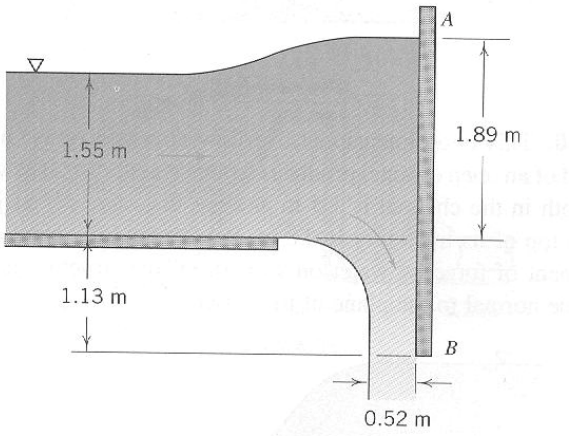
Q = 6.11 MGD

2. (20 pts) Water discharges into the atmosphere through the odd-looking nozzle depicted below in cross-section. Determine the *x* and *z* components of the force of the water on the flange bolts. You may neglect the weight of the nozzle and water. (**English system**)



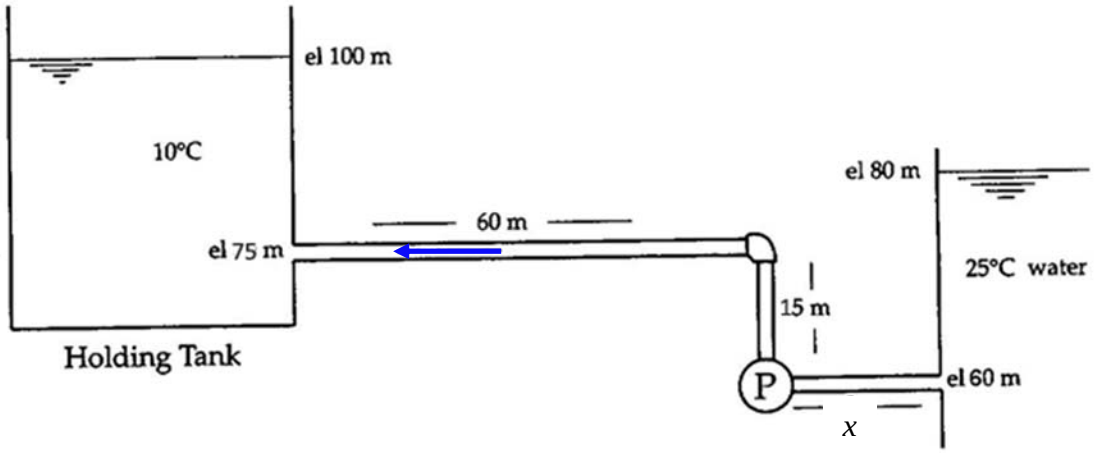
Fw_x = 2441 lbs (to the right)
Fw_z = 26.5 lbs (upward)

3. (25 pts) Flow (left to right) at the end of a canal of constant width is deflected vertically downward by the gate AB. Determine the horizontal force exerted by the water on the gate per unit width, assuming negligible head loss. The downward flow at B is open to the atmosphere (i.e. a free jet). **SI system**



Fw_x = 22.1 kN per m of width (to the right)

4. (30 pts) The 6-cm diameter pipeline shown below connects a reservoir (on the right) with a holding tank (on the left). The 85% efficiency pump provides a flow rate of 1.2 cubic meters per minute to the holding tank (from *right to left*). The frictional head loss is given by $0.03(L/D)V^2/2g$ and there is a loss of $0.5V^2/2g$ at the elbow. The entrance loss is negligible. **SI system**

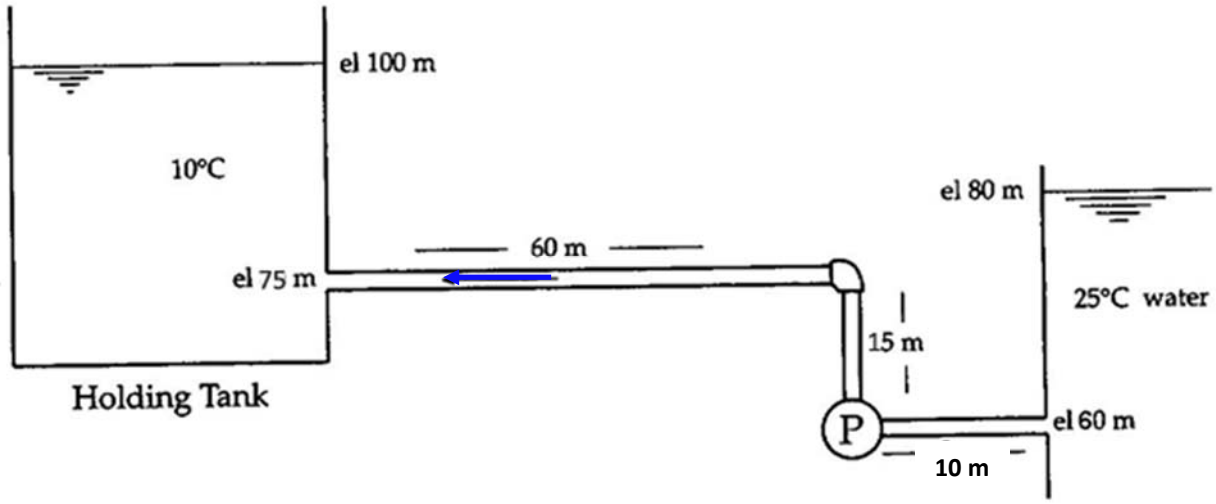


(a) For x = 10 m, how much power is required to run the pump?
(b) What is the max distance x away from the reservoir that the pump could be located to avoid cavitation at the pump inlet?

Power = 27.5 kW
x = 21.5 m

4(c) Carefully draw the EGL and the HGL of the system from part (a). Label important features

(Ans not provided – expectation is a scaled drawing that is drawn with a straight-edge)



Conversion Factors etc.

g = acceleration of gravity = 9.81 m/s^2 = 32.2 ft/s^2
p_{atm} (standard conditions) = 14.7 psi = 101.3 kPa
air-water surface tension (σ) at 20°C = 0.0728 N/m
temperature lapse rate in the troposphere (α) = 0.00587 K/m

Lbf = slug-ft/sec^2 1 hp = 550 ft-lbs/sec
N = kg-m/sec^2 Pa = N/m2 Joule = N-m Watt = Joule/sec

1 mile = 5280 ft 1 km = 1000 m
1 ft = 12 inches 1 m = 100 cm = 1000 mm
1 ft^3 = 7.48 gal 1 gal = 3.785 L 1 m^3 = 1000 L = 10^6 mL
1 in = 2.54 cm 1 m = 3.28 ft

1 psi ≈ 2.3 ft of water
cfs = cubic feet per second gpm = gallons per minute MGD = million gallons per day

K = °C + 273 R = °F + 460