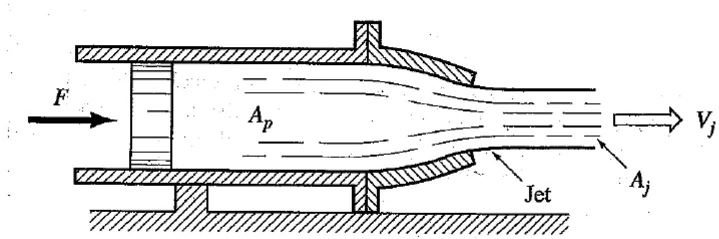
Homework #7 – Part 1

Due: Friday 03/13/2015

(2 problems; 10 points total)

1.[5 points] In the book *The Hunt for Red October* a Russian submarine is described which uses a silent ``caterpillar'' drive instead of a propeller. Even though the propulsion system is very quiet the submarine may still make a lot of noise if it goes too fast. The reason is that, if the speed of the submarine is too great, the static pressure at the point of maximum velocity over the submarine will drop below the vapor pressure for saturated water and the water will boil or cavitate. When the bubbles that form collapse, they make a lot of noise, making it easy to detect the submarine. The flow will not cavitate as long as the static pressure is greater than the vapor pressure of saturated water, p_v. For the purposes of this problem, assume the ocean has a uniform density ρ = 1000 kg/m^3, atmospheric pressure acting on the surface of the ocean is p_a = 101kPa (1.01x10^5 N/m^2), the acceleration due to gravity is g = 9.81 m/s^2, the vapor pressure of saturated water at 12 ^{o}C is p_v = 1.4 kPa, and that the entire ocean has a uniform temperature of 12 ^{o}C. If the maximum velocity over the surface of the submarine is 2.0 times the freestream velocity, how fast can the submarine go at a depth of 100 m without cavitating? In order to go faster without being detected should the submarine increase or decrease its depth? Explain your answer.

2.[5 points] The jet of water is generated by applying a steady force F=100 N on a piston (see figure below). The area of the piston is A_p=0.002 m^2 and the jet is A_j=0.0005 m^2. Assume that the flow to the right of the piston is steady and friction losses may be neglected. The fluid density is 1000 kg/m^3 and the atmospheric pressure is p_a=100 kPa. The back of the piston is open to atmospheric pressure. Assume the jet area is the same as the exit area of the nozzle. Find the jet velocity V_j.



Quote of the week:

"There is no philosophy which is not founded upon knowledge of the phenomena, but to get any profit from this knowledge it is absolutely necessary to be a mathematician. " - Daniel Bernoulli, 1700-1782