Massachusetts Institute of Technology
Department of Aeronautics and Astronautics
Cambridge, MA 02139

16.003/16.004 Unified Engineering III, IV
Spring 2009

Problem Set 13

Name: ________________________

Due Date: N/A

	Time Spent (min)
S19	
S20	
F19	
F20	
Study Time	

Announcements:

S19:

Please do the following problems from Oppenheim and Willsky.

3.25
3.33
3.40 (a), (b), (d)

S20:

Please do the following problems from Oppenheim and Willsky.

4.21 (b), (c), (d)
4.32 (a), (c)
4.33 (a), (b)

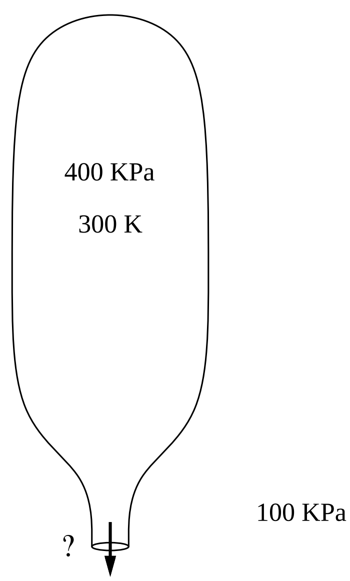
Note: This is the same as F19 on the 2007 Pset9 in the UE Archive

A water rocket built from a 2-liter water bottle, sketched below, is pumped up to 400 KPa absolute pressure (about 60 psi). There is no water in the rocket, just the pressurized air. The pumping is done slowly, so that the rocket air stays at the ambient temperature of 300 K. The atmospheric pressure is 100 KPa. The minimum nozzle area is $4\,\mathrm{cm}^2$.

a) Explain why the airflow at the nozzle is locally at $M = 1$ (and not at $M > 1$) when the rocket is launched.

b) At the instant the flow starts, with the inside pressure still nearly at its initial value, determine the following quantities at the nozzle: ρ, p, T, u.

c) Determine an absolute minimum amount of time the air flow will last.
Hint: Determine the initial mass flow through the nozzle.



Unified Engineering Spring 2009
Fluids Problems F20

Note: This is the same as F19-20 on the 2008 Pset15b in the UE Archive

a) Anderson problem 10.1 (p 655).

b) Anderson problem 10.2 (p 655).

c) Anderson problem 10.7 (p 655).

d) Anderson problem 10.9 (p 656).