Homework Set #36

Problem 1: (Reconciliation between the compressible and the incompressible models)
The *incompressible* Bernoulli's equation gives the following relationship between the stagnation and the static pressure

$$P_0 = P + \frac{1}{2}\rho V^2 .$$

However, our *compressible* flow analysis gives the following stagnation-to-static pressure ratio for an ideal gas

$$\frac{P_0}{P} = \left(1 + \frac{k-1}{2} M^2\right)^{k/k-1} .$$

Assume $k = 1.4$ (air) for the following questions.

a) Plot the stagnation-to-static pressure ratio over the range $0 < M < 1$ for both the incompressible and the compressible models.

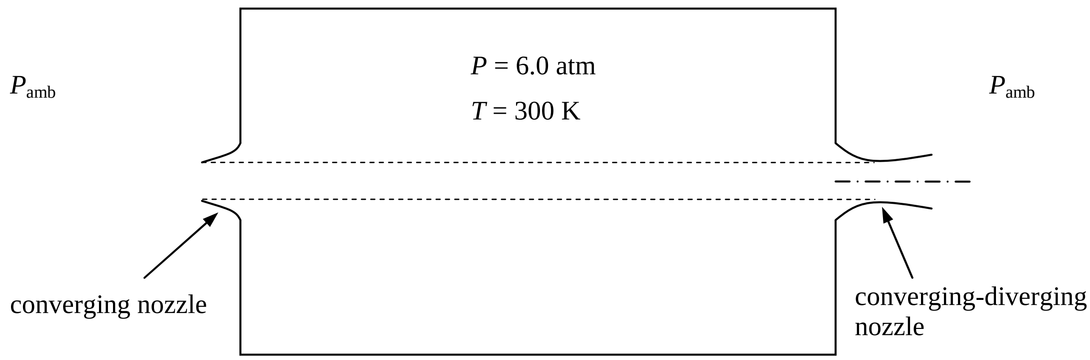
b) Fill out the following table

	$\frac{P_0}{P}$ (incompressible)	$\frac{P_0}{P}$ (compressible)	% difference between the two models
$M = 0.10$			
$M = 0.30$			
$M = 0.70$			
$M = 1.0$			
$M = 2.0$			
$M = 3.0$			

c) Determine the difference between the two models as a function of Mach number. **(Hint: Perform a binomial expansion on the compressible model and then your results with the incompressible model.)**

Problem 2: (Compressible flows in converging and converging-diverging nozzles)

A large supply chamber containing air at 6.0 atm and 300 K is connected to a converging nozzle on the left side and a converging-diverging (C-D) nozzle on the right side. Both nozzles share the same minimum throat area of 100 cm^2. The C-D nozzle has an exit-to-throat area ratio of 1.2.



Assume the reservoir is large enough so that the supply pressure and temperature do not change significantly during the discharge process.

a) Determine the pressure and temperature at the exit of the converging nozzle.
b) Determine the mass flow rate through the converging nozzle.
c) Determine the mass flow rate through the converging-diverging nozzle.