Solution to Problem 332A:

For the purposes of an experiment we wish to design a convergent/divergent nozzle (a de Laval nozzle) which will be supplied from a compressed air reservoir ($\gamma = 1.4$). It is required that (1) there is a normal shock across the exit of the diffuser and (2) that the jet emerging downstream of the shock should have a Mach number of 0.5.

Since $M = 0.5$ just downstream of the shock at the exit, it follows from the normal shock wave table that $M = 2.65$ upstream of the shock and that $p_E/p_{E1} = 8.026$ where p_{E1} is the pressure just upstream of the exit shock. Then

(a) Since the rest of the flow in the convergent/divergent nozzle is isentropic, we may use the isentropic flow table to look up $M = 2.65$ and find that the ratio of the cross-sectional area at the diffuser exit to the cross-sectional area of the throat, $A_E/A^* = 3.036$, and that $p_{E1}/p_0 = 0.046$.

(b) Also then the ratio of the pressure downstream of the exit shock to the throat pressure,

$$\frac{p_E}{p^*} \;=\; \frac{p_E}{p_{E1}}\frac{p_{E1}}{p_0}\frac{p_0}{p^*} \;=\; 8.026 \times 0.046/0.528 \;=\; 0.699 \tag{1}$$

(c) and the ratio of the pressure downstream of the shock to the pressure in the compressed air reservoir, $p_E/p_0 = 8.026 \times 0.046 = 0.369$.