PROBLEM NO. 16.5	MECHANICAL ENGINEERING DEPARTMENT	NAME
DATE		SECTION

Given: Determine the stagnation temperature and stagnation pressure of air flowing at

Find: 44 kPa

245.9 K

Relationships: 470 m/s

* Assume constant specific heats

$$T_0 = T + \frac{V^2}{2C_p}$$

System Sketch or FBD

Solution:

$C_p = 1.005\ \text{kJ/kg K}$ at 300 K

$K = 1.400$ Table A-2

$$T_0 = 245.9\ \text{K} + \frac{(470\ \text{m/s})^2}{2 \cdot 1.003\ \text{kJ/kg K}} \cdot \frac{\text{kJ/kg}}{1000\ \text{m}^2/\text{s}^2}$$

$$T_0 = 245.9\ \text{K} + 109.9\ \text{K}$$

$$T_0 = 355.8\ \text{K}$$

$$\frac{P_0}{P} = \left(\frac{T_0}{T}\right)^{K/(K-1)} = \left(\frac{355.8\ \text{K}}{245.9\ \text{K}}\right)^{1.4/.4}$$

$$P_0 = 160.3\ \text{kPa}$$

PROBLEM NO. 16.20	MECHANICAL ENGINEERING DEPARTMENT	NAME
DATE		SECTION

Given: Carbon dioxide enters an adiabatic nozzle at 1200K with velocity of 50 m/s and leaves at 400 K

Find: Determine the Mach Number

Relationships: a) Inlet

$$C = \sqrt{KRT}$$

Table A-2

$K = 1.181$ at 1000K

$R = 0.1889$ kJ/kg K

System Sketch or FBD

Solution:

$$C = \sqrt{1.181\,(0.1889\ \text{kJ/kg K})(1200\text{K}) \cdot \frac{1000\ \text{m}^2/\text{s}^2}{\text{kg/kJ}}}$$

$$C = 517.4\ \text{m/s}$$

$$M = \frac{V}{C} = \frac{50\ \text{m/s}}{517.4\ \text{m/s}} = .0966$$

b) Exit

at $T_{avg} = 800$K

$C_p = 1.169$ kJ/kg K

$$h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

$$\frac{V_2^2}{2} = C_p\left[T_1 - T_2\right] + \frac{V_1^2}{2}$$

$$V_2 = \sqrt{2C_p\left[T_1 - T_2\right] + V_1^2}$$

$V_2 = 1368$ m/s

$T = 400$K

$K = 1.252$

$C = \sqrt{KRT}$

$C = 307.6$ m/s

$M_2 = 4.45$

PROBLEM NO. 16.37	MECHANICAL ENGINEERING DEPARTMENT	NAME
DATE		SECTION

Given:

Air enters a converging - diverging nozzle at 1.2 MPa with negligible velocity.

Find:

What is the lowest pressure that can be obtained in the throat?

Relationships:

In the converging portion of the nozzle the flow can only reach sonic velocity

System Sketch or FBD

Solution:

$$P_0 = 1.2 \text{ MPa}$$

when $M = 1 \rightarrow$ Critical Pressure

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

$$P^* = 633.9 \text{ kPa}$$