3 #. a) initial heating $V = \text{const}$

initial state: P_i, T_a, $\rho_i = \frac{m}{V} = \text{const}$

after heating

$$\frac{P}{P_i} = \frac{\rho_i R T_{hot}}{\rho_i R T_a} = \frac{T_{hot}}{T_a} \qquad P = P_i \frac{T_{hot}}{T_a}$$

but

$$P_i A = P_a A + Mg \qquad P_i = P_a + \frac{Mg}{A}$$

$$\Rightarrow \boxed{P = \left(P_a + \frac{Mg}{A}\right) \frac{T_{hot}}{T_a}} = P_{hot}$$

b) when cylinder moves

$$V = xA \qquad (\text{initial } V = hA)$$

$$\sum F = Ma \qquad + \uparrow$$

$$\Rightarrow$$

$$PA - P_a A - Mg = M \frac{d^2x}{dt^2}$$

isentropic from hot initial state

$$\frac{P}{P_{hot}} = \left(\frac{\rho}{\rho_{hot}}\right)^\gamma \Rightarrow P = P_{hot} \left(\frac{m/V}{m/V_i}\right)^\gamma = P_{hot} \left(\frac{hA}{xA}\right)^\gamma$$