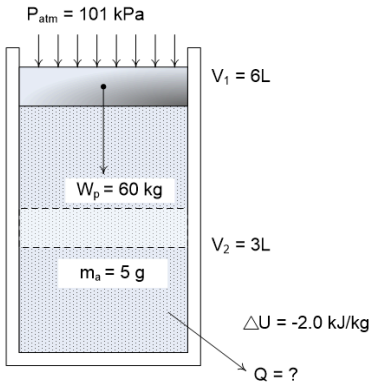

A piston-cylinder assembly trapping a fixed mass of working substance is classified as a **Closed System** or a **Non-Flow System**. In a closed system, mass is strictly contained within its boundaries and cannot cross the control perimeter, but energy is free to cross in the forms of heat (Q) and work (W).

We will first assume that the direction of the heat flow is going out of the system, if our final answer is positive, it simply means that our assumption is correct. To evaluate the thermodynamic behavior of this system, we apply **The First Law of Thermodynamics for a Closed System**, which represents the conservation of energy principle:

$$\left[E_{in} = E_{out}\right]$$

$$U_1 = W_{NF} + Q + U_1$$

$$-Q = W_{NF} + \Delta U$$

For Work non flow, W_{NF}:

$$W_{NF} = P\int_1^2 dV = P\left(V_2 - V_1\right)$$

$$P = \frac{F}{A} = \frac{m}{A}\left(\frac{g_o}{g_c}\right) = \frac{60\ kg}{0.15\ m^2}\left(\frac{9.81\frac{m}{s^2}}{1000\frac{kg-m}{kN-s^2}}\right) = 39.24\ kPa$$

$$W_{NF} = (101 + 39.24)kPa(0.003 - 0.006)m^3$$

$$W_{NF} = -0.4207\ kJ$$

The work value is **negative**, confirming that work is being done *on* the air system by the heavy piston compressing it downward.

Substituting;

$$-\ 2.0\ kJ\ =-\ 0.4207\ kJ\ +\ \Delta U$$

$$\Delta U\ =-\ 1.57928\ kJ$$

In terms of kJ/kg

$$\Delta u\ =\frac{Q}{m}=\frac{-1.57928\ kJ}{0.005\ kg}\ =-\ 315.856\frac{kJ}{kg}$$

As the cylinder radiates -2.0 kJ of heat away into the cold surrounding environment, the internal air drops in temperature and shrinks. As it shrinks, gravity pulls the heavy 60 kg piston downward, executing +0.4207 kJ of compressive mechanical work *on the air*. This compression work acts as an energy input, partially offsetting the massive thermal loss. Instead of dropping by the full 2.0 kJ, the air's internal energy drop is mitigated to -1.579 kJ