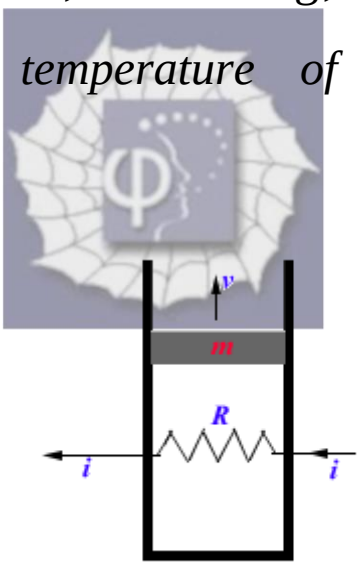
396.

Problem 32.55 (RHK)

A resistance coil, wired to an external battery, is placed inside an adiabatic cylinder fitted with a frictionless piston and containing an ideal gas. A current $i = 240\ \text{mA}$ *flows through the coil, which has a resistance* $R = 550\ \Omega$. *We have to calculate the speed* v *with which the piston,* $m = 11.8\ \text{kg}$, *will move upward in order that the temperature of the gas remains unchanged.*



Solution:

Resistance of the coil is $R = 550\ \Omega$. Current flowing through the coil is $i = 240\ \text{mA}$. Therefore, the rate at which Joule energy is being produced inside the cylinder is

$$P = i^2 R = \left(240 \times 10^{-3}\right)^2 \times 550 \text{ W} = 31.68 \text{ W}.$$

If the temperature of the gas inside the cylinder has to remain unchanged, the piston will move up with speed such that the gravitational potential energy of the piston equals P. That is

$$P = mgv.$$

We thus find the speed with which the piston will be moving up to be

$$v = \frac{31.68}{11.8 \times 9.81} \text{ m s}^{-1} = 0.2737 \text{ m s}^{-1} = 27.4 \text{ cm s}^{-1}.$$