Physics Cup – Problem 4

The electron moves in a circle perpendicular to the magnetic field, so it needs to satisfy the quantization condition $rmv = \frac{m^2v^2}{eB} = n\hbar$, where r is the radius of circular motion, v is the velocity of the electron and $n = 0,1,2,\cdots$. So $v = \frac{\sqrt{n\hbar eB}}{m}$, and because $\frac{\sqrt{\hbar eB}}{m} \gg \sqrt{\frac{k_BT}{m}}$, most electrons have no velocity component perpendicular to the magnetic field. Therefore, we consider the electron gas as one-dimensional gas.

While the shock wave is traveling through the space, the potential field changes slowly. So before and after the shock wave travels through the space, the adiabatic invariant is the same, and the electron gas is in the same external conditions except that the potential increases by U_0. Therefore, all physical quantities except potential are the same before and after the shock wave travels through the space. So the pressure exerted on the walls after the shock wave has traveled through the entire space of length L between the walls is p_0, same as what it is initially.