1. The question asks "inductance per unit length", which is $\frac{L}{l}$, l is the length of the solenoid. Since $L = \frac{N\phi}{I}$ (not $\frac{n\phi}{I}$!!) and $N = nl$. We can get $\frac{L}{l} = \frac{n\phi}{I}$. Recall that for long solenoid $\phi = BS = \mu n I S$. thus $\frac{L}{l} = \frac{n(\mu n I S)}{I} = \mu n^2 S$. ($\mu$ here refers to the permeability of the core of the solenoid, i.e. $\mu = \mu_0 \mu_r$, μ_r is the relative permeability)

2. From the right picture of question 2, you may find the magnetic flux go through R_1, R_2, R_3 is ϕ_1, ϕ_2, $(\phi_1+\phi_2)$, respectively. So we can get

$$\begin{cases} N_1 I_1 = \phi_1 R_1 + (\phi_1+\phi_2) R_3 \text{ (by KVL for Magnetostatic loop)} \\ N_2 I_2 = \phi_2 R_2 + (\phi_1+\phi_2) R_3 \end{cases}$$

$$\Rightarrow \begin{cases} N_1 I_1 = (R_1+R_3)\phi_1 + R_3\phi_2 \quad \text{—①} \\ N_1 I_1 - N_2 I_2 = \phi_1 R_1 - \phi_2 R_2 \end{cases} \Rightarrow \phi_2 = \frac{\phi_1 R_1 - N_1 I_1 + N_2 I_2}{R_2}, \text{ substitude into ①.}$$

$$\Rightarrow N_1 I_1 = (R_1+R_3)\phi_1 + \frac{R_3}{R_2}(\phi_1 R_1 - N_1 I_1 + N_2 I_2) \Rightarrow N_1 I_1 \left(1+\frac{R_3}{R_2}\right) - N_2 I_2 \frac{R_3}{R_2} = \left(R_1 + R_3 + \frac{R_1 R_3}{R_2}\right)\phi_1$$

$$\Rightarrow \phi_1 = \frac{N_1 I_1 (R_2+R_3) - N_2 I_2 R_3}{R_1 R_2 + R_2 R_3 + R_1 R_3} \quad ※$$

※ You could define the directions of Φ_1, Φ_2 at different ways, but make sure that the directions are consistent. (And better draw it out)

3. Recall that characteristic time constant for RL circuit is $\tau = \frac{L_{total}}{R'}$, which L_{total} is the equivalent inductance of the whole circuit. To have a minimum τ_{min}, we should minimize L_{total} and maximize R. Since we only have a resistor with resistance R, $R' = R$ is confined. And to minimize L_{total} with 10 inductors with inductance L, we should connect them in parrallel, which $\frac{1}{L_{total}} = \underbrace{\frac{1}{L} + \frac{1}{L} + \cdots + \frac{1}{L}}_{10} = \frac{10}{L} \Rightarrow L_{total} = \frac{L}{10}$. In this case,

$\tau_{min} = \frac{L}{10R}$ ※