Hint 1 $\quad F2 \Leftrightarrow F1$

$$0 = \frac{D}{Dt}\iiint_V \rho \, dV$$

$$\neq \iiint_V \frac{D\rho}{Dt} dV \text{ , } \quad \text{but}$$

$$= \iiint_V \frac{D(\rho dV)}{Dt} \text{ , since in F2,}$$

V varies in space & time,

so does dV.

Also, use the definition of

$\nabla \cdot \underline{u} = 0$,

Hint 2

$u^\varepsilon(\xi, \tau)$ is a soln to Eq (1)

means

$$u^\varepsilon_\tau + a u^\varepsilon_\xi = \varepsilon u^\varepsilon_{\xi\xi} \text{, rather than}$$

$$u^\varepsilon_t + a u^\varepsilon_x = \varepsilon u^\varepsilon_{xx} .$$

(Typo) Eqn (5) needs to be

$$\lim_{\varepsilon \to 0} u^\varepsilon(x,t) = \lim_{\varepsilon \to 0} v^\varepsilon(\xi - a\tau, \tau)$$

$$= u_0(\xi - at)$$

(Typo) The answer to the second part of Prob 3(a), i.e, "find $v^\varepsilon(x,t)$" is already given in Hint 1, (Too much hint ☺ sometimes confuses you!)

Hint 3 You want $u_x \to \infty$. to find t_b.

Important things to consider :

$$\xi = x - u_0(\xi)t = \underline{\underline{\xi(x,t)}}$$

fn of x & t

(1) Consider $\frac{\partial \xi}{\partial x}$ & $\frac{\partial \xi}{\partial t}$

From $u(x,t) = u_0(\xi)$, consider

$$\frac{\partial u}{\partial x} = \cdots \quad \longrightarrow \infty.$$