

Problem 2C.2

Residence time distribution in tube flow. Define the *residence time function* $F(t)$ to be that fraction of the fluid flowing in a conduit which flows completely through the conduit in a time interval t . Also define the *mean residence time* t_m by the relation

$$t_m = \int_0^1 t dF \quad (2C.2-1)$$

- (a) An incompressible Newtonian liquid is flowing in a circular tube of length L and radius R , and the average flow velocity is $\langle v_z \rangle$. Show that

$$F(t) = 0 \quad \text{for } t \leq (L/2\langle v_z \rangle) \quad (2C.2-2)$$

$$F(t) = 1 - (L/2\langle v_z \rangle t)^2 \quad \text{for } t \geq (L/2\langle v_z \rangle) \quad (2C.2-3)$$

- (b) Show that $t_m = (L/\langle v_z \rangle)$.