P 16-11 → See accompanying Excel file

a) Plot $C(t)$ Vs t

Obtain $E(t)$ by →

$$E(t) = \frac{C(t)}{\int_0^\infty C(t)dt} \quad \therefore \text{ From graph } \int_0^\infty C(t)dt = 0.1$$

$$E(t) = \frac{C(t)}{0.1}$$

b) Obtain $F(t)$ as

$$F(t) = \int_0^t E(t)\,dt.$$

→ divide $E(t)$ curve in 3 parts.

→ Fit polynomial

→ Integrate polynomial to obtain value.
(I used wolfram Alpha to get integral values)

c) Mean residence time

$$t_m = \int_0^\infty t E(t) dt.$$

→ plot $t E(t) dt$

→ calculate area under curve

$t_m = 9.88$ min $\doteqdot$ 10 min

Variance

$$\sigma^2 = \int_0^\infty (t - t_m)^2 E(t) dt$$

→ plot $(t - t_m)^2 E(t)$

→ calculate area under curve

$\sigma^2 = 73.81 \text{ min}^2 \doteqdot 74 \text{ min}^2$

d) Fraction of material that spends between 2 and 4 min

$$= \int_2^4 E(t)\,dt = 0.16$$

→ Use fitted polynomial / graph

e) Fraction of material that spends longer than 6 min

$$= \int_6^\infty E(t)\,dt = 0.581$$

f) Fraction of material that spends less than 3 min

$$= \int_0^3 E(t)\,dt = 0.192$$

g) Normalized distributions

Normalized RTD

$$\Theta = \frac{t}{\tau}$$

$$E(\Theta) = \tau E(t) \longrightarrow \text{plot } \tau E(t)$$

Normalized cumulative RTD

$$F(\Theta) = \int_0^\Theta E(\Theta)\,d\Theta = \int_0^\Theta E(t)\,dt$$

└ same graph as $F(t)$ but x axis goes from 0 to Θ

h) Reactor volume

$$F = 10 \text{ dm}^3/\text{min}$$

$$V = F \cdot \tau = 100 \text{ dm}^3$$

i) Internal age distribution

$$I(t) = \frac{1}{\tau}\left[1 - F(t)\right]$$

j) Mean internal age

$$\alpha_m = \int_0^\infty I(t)\,dt$$

From graph

$\alpha_m = 1$ min .