0in
R_e small – laminar flow.
R_e large – turbulent flow.

Why is R_e useful

Prototyping (p) using a model (m)

1. Geometric similarity
2. Kinematic or dynamic similarity

Assuming

1. materials are the same
2. both in the same medium

then

$$\begin{aligned}
\rho_p &= \rho_m \\
\mu_p &= \mu_m \\
R_{e_p} &= R_{e_m} \\
\frac{R_m v_m \rho_m}{\mu_m} &= \frac{R_p v_p \rho_p}{\mu_m} \\
v_m &= \frac{R_p v_p \rho_p \mu_m}{\mu_m R_m \rho_m} \\
&= \frac{\rho_p}{\rho_m} \times \frac{\mu_p}{\mu_m} \times \frac{R_p v_p}{R_m} \\
&= \frac{R_p}{R_m} v_p
\end{aligned}$$

Chapter 2

Scaling and Nondimensionality

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{k}\right), \quad p(0) = p_0$$

$$p = f(t, r, k, p_0)$$

- $[p] = \#$
- $[t] = T$
- $[p_0] = \#$

$$\frac{dP}{dt} = rP - \frac{rP^2}{k}$$

- $\left[\frac{dP}{dt} = \frac{\#}{T}\right]$
- $[rP] = [r][P] =$

$$\begin{aligned} p &= f(t, r, k, p_0) \\ [p] &= [t]^a [r]^b [k]^c [p_0]^d \\ T^0\# &= T^a (T^{-1})^b \#^c \#^d \\ T^0\# &= T^a T^{-b} \#^c \#^d \\ T^0\# &= T^{a-b} \#^{c+d} \end{aligned}$$

Chapter 3

Chemical Diffusion

Molecules or particles in a fluid

We do not want to track number – to large! Measure concentration instead of number.

3 Dimensional $[concentration] = \frac{M}{Volume} = \frac{M}{L^3}$
Flux $J(x,t)$ = the amount of substance that passes through x in the positive direction per unit time. (If flow goes to the left: $J < 0$)

rate of change of amount:

$$\frac{d}{dt}\int_a^b c(x,t)dx = J(a,t) - J(b,t) \tag{3.1}$$

$$\int_a^b \frac{\partial c}{\partial t}dx = -\int_a^b \frac{\partial J}{\partial x}dx \tag{3.2}$$

$$\int_a^b \left(\frac{\partial c}{\partial t} + \frac{\partial J}{\partial x}\right) dx = 0 \tag{3.3}$$

What is the flux – J? Chemical diffusion – how does the flow depend on the concentration?

Chemical moves from region of high concentration to low concentration.

$$J \propto -\frac{\partial c}{\partial x} \tag{3.4}$$