Department of Chemical and
Biological Engineering

CBE 341 – Mass, Momentum, and Energy Transport

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Lecture 3 09/17/17

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DIMENSIONAL ANALYSIS

1. Problems of practical interest cannot always be solved exactly by analytical methods

2. We wish to conduct as few experiments as possible…

3. …while working with a suitably scaled model of the geometry of interest

4. expose dimensionless groups (or parameters) which can be used to correlate the experimental data,

5. which allows us to use the correlations across geometric scales.

6. examine the exact equations of motion critically. By recasting these equations in a dimensionless form, one can recognize the relative importance of various terms in the model equations.

DIMENSIONAL ANALYSIS

Does not require as a starting point the differential equations describing the evolution of various variables

Buckingman Pi theorem

q_i with $i \in [\![1, n]\!]$ $\quad q_1, q_2 \cdots q_n \quad q_1 = f(q_2, \cdots q_n)$

or $g(q_1, \cdots, q_n) = 0$

this problem can be rewritten in terms of a set of $p = n - k$ dimensionless parameters $\pi_1, \pi_2, \cdots, \pi_p$

$$F(\pi_1, \cdots, \pi_p) = 0$$

where k is the number of independant physical units

$$\pi_i = q_1^{a_1} q_2^{a_2} \cdots q_n^{a_n}$$

with a_i rational numbers (or eq. integers)