

CIEG 305 HANDOUT ON DIMENSIONAL ANALYSIS

Recipe for performing dimensional analysis on a problem.

1. List all variables involved in problem (usually given)
2. Express each of the n variables in terms of the r basic dimensions (Length, Mass, Time)
3. Determine required number, k , of Pi terms ($k = n - r$), for us $r = 3$.
4. Select a number of repeating variables, where the number required is equal to the number of fundamental (basic) dimensions. For us 3, usually length (or height or diameter; some length variable) and velocity and density.
5. Form a pi term by multiplying one of the nonrepeating variables by the product of repeating variables each raised to an exponent that will make the combination dimensionless.
6. Equate this product to the combination $M^0 L^0 T^0$.
e.g. for μ $(ML^{-1}T^{-1})(L)^a (LT^{-1})^b (ML^{-3})^c = M^0 L^0 T^0$
7. Solve for the exponents explained in steps 5,6 by forming 3 equations, one each for M, L and T such that the exponents on the left hand side = 0.

$$M : 1 + c = 0 \rightarrow c = -1$$

$$\text{e.g. for } \mu \quad T : -1 - b = 0 \rightarrow b = -1$$

$$L : -1 + a + b - 3c = 0 \rightarrow a = -1$$

8. Form dimensionless group based on the exponents you solved for.
e.g. for μ $\Pi_1 = \frac{\mu}{\rho d u}$, where d may be the diameter and u the velocity (i.e. a length and velocity variable).
9. Repeat steps 5-8 for each of the remaining nonrepeating variables.
10. Check all resulting Pi terms to make sure they are dimensionless.