\[ T_{11} = \mu \mathbf{D}^{-1} \mathbf{U}_2 \mathbf{g}^{-1} \]

\[ T_{11} = \mu \begin{bmatrix} \mathbf{D} & \mathbf{U}_2 \end{bmatrix} \mathbf{g}^{-1} = \mathbf{M} \mathbf{L} \mathbf{T} \]

\[ (\frac{M}{L^2})^a (\frac{L}{c})^b (\frac{M}{L^2})^c = \mathbf{M} \mathbf{L} \mathbf{T} \]

\[ 1+c \quad -1+a+b-3c \quad -1-b \]

\[ \mathbf{M} \mathbf{L} \mathbf{T} = \mathbf{M} \mathbf{L} \mathbf{T} \]

\[ \begin{cases} 1+c = 0 & c = -1 \\ -1+a+b-3c = 0 & a = -1 \\ -1-b = 0 & b = -1 \end{cases} \]
Step #4: form/derive the \((n-m)\) \(\mathcal{T}\) parameters

\[
n = 5
\]
\[
m = 3
\]
\[
n - m = 5 - 3 = 2
\]

\[
F = f(D, \alpha, \gamma, \mu) \rightarrow \mathcal{T}, = g(\mathcal{T}_2)
\]
Step #3: Pick $m$ repeating parameters
(no repeating parameter should have dimensions that are a power of the dimensions of another repeating parameter)

\[
\{ \mathcal{D}, \mathcal{U}_0, \mu \} \quad \{ \mathcal{D}, \mathcal{g}, \mu \} \\
L \perp M \\
L \perp M
\]

pick this set
Step #2: Identify all the fundamental units involved in problem

\[
\begin{align*}
[F] &= M \frac{L}{t^2} \\
[L] &= L \\
[\text{ms}] &= \frac{L}{t} \\
[S] &= \frac{M}{L^3} \\
[M] &= \frac{M}{L^2t} 
\end{align*}
\]

So, we have a total of 3 fundamental units

\[m = 3\]
Application of IT Theorem

Example: Drag force $F$ over a smooth sphere at low speed. Neglect gravity

$U_0$  
$\rightarrow$  
$
$  
Step #1: List all parameters involved in problem

$F = f(D, U_0, g, \mu)$  
$\circ^\circ \ n = 5$
Consider a sphere

\[ V \rightarrow D \]

Read section 7-3: Buckingham $\Pi$ Theorem
Lecture 11/9/06

Chapter 7 Dimensional Analysis