Experiments give \( \omega_m = 49.9 \text{ Hz} \)

\[
\left( \frac{\omega}{DN} \right)_m = \left( \frac{\omega}{DN} \right)_p
\]

\[ \Rightarrow \omega_p = 29 \text{ Hz} \]
\[ \frac{g_{\text{H}_2\text{O}} \cdot v_m \cdot D_m}{m_m} = \frac{g_{\text{air}} \cdot v_p \cdot D_p}{M_p} \]

\[ V_m = V_p \left( \frac{\rho_p}{\rho_m} \right) \left( \frac{g_m}{g_{\text{air}}} \right) \left( \frac{m_m}{M_p} \right) \]

\[ 1.79 \times 10^{-5} \frac{\text{g}}{\text{m} \cdot \text{s}} \]

\[ 5 \text{ dm/s} = \frac{5 \text{ dm}}{\text{s}} \]

\[ \frac{1}{1050} \]

\[ V_m = 13.9 \text{ m/s} \]
\[ w = f(D, g, \mu, V) \]

**Dimensional analysis**

\[ \frac{w}{D/V} = f(Re_D) \]

**Dynamic similarity requires**

\[ (Re_D)_m = (Re_D)_p \]
Example

\[ V_p = 50 \text{km/hr} \quad D_p = 0.1 \text{m} \]

shedding frequency \( w \)?

\[ \text{structured element} \]

want to build a model 1:5 scale
model to be tested in water

\[ V_m = ? \quad W_m \rightarrow \text{get} \ w_p = ? \]
Similitude: predicting prototype conditions from experimental results of model

Must satisfy 2 conditions:

1. Geometrical similarity
2. Dynamic similarity  
   (match the t's)
\[ Re_D = \frac{g V D}{\mu} = \frac{(1.99)(8.44)(1 \text{ ft})}{3.34 \times 10^{-5}} \]

\[ Re_D = 5 \times 10^5 \]

From figure, assuming smooth sphere
\[ C_D = 0.09 \]

\[ C_D = \frac{F}{\frac{1}{2} g V^2 D} = 0.09 \implies F = \frac{0.09}{2} g V^2 D \\
= 6.4 \text{ lb} \]
Example
(a) design a sonar pulled by helicopter would like to know force required to pull sonar

\[ V = 5 \text{ mph} = 8.44 \text{ ft/s} \]

\[ D = 1 \text{ ft} \]

\[ g = 1.99 \text{ slug/ft}^3 \]

\[ \mu = 3.34 \times 10^{-5} \text{ slug/ft - sec} \]
\[
F = f(D, \mu_0, \delta, \varepsilon)
\]

\[
\frac{F}{2g \mu_0 D^2} = f(Re, \frac{\varepsilon}{\delta})
\]
$F = \frac{1}{8}\mu u_0^2 D^2 = f(\text{Re}_D)$

$Re_D = \frac{u_0 D}{\nu}$

Kinematic viscosity $\nu = \frac{\mu}{\rho}$