

2.20 Marine Hydrodynamics Homework #3(b)
Due: October 6, 2009

Question 1:

Solve from the supplemental problems:

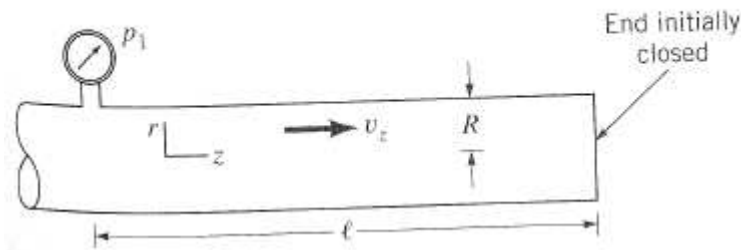
1. Ma5
2. M18

Question 2:

You are asked to design an oil tanker which is 100 meters long and has a cruising speed U_{Tanker} . In order to understand the ship's response you decide to do a scaled model test in a towing tank which is filled with water. Your dimensional analysis shows that the relevant similarity parameters are the Reynolds number ($Re = \frac{UL}{\nu}$) and the Froude number ($Fr = \frac{U^2}{gL}$). You are also subjected to the constraint that on earth gravity is constant. In order to satisfy both of these scaling conditions, what length scale must you use? Do you see any problems doing a model test at this length scale? What alternatives could you suggest to make this scaling possible?

Question 3:

7.69 from Fund. of Fluid Mech. by Munson, Young, and Okiishi (5th Ed.)



A liquid is contained in a pipe that is closed at one end as shown in the figure below. Initially the liquid is at rest, but if the end is suddenly opened the liquid starts to move. Assume that the pressure (p_1) remains constant. The differential equation that describes the resulting motion of the liquid is:

$$\rho \frac{\partial v_z}{\partial t} = \frac{p_1}{l} + \mu \left(\frac{\partial^2 v_z}{\partial r^2} + \frac{1}{r} \frac{\partial v_z}{\partial r} \right)$$

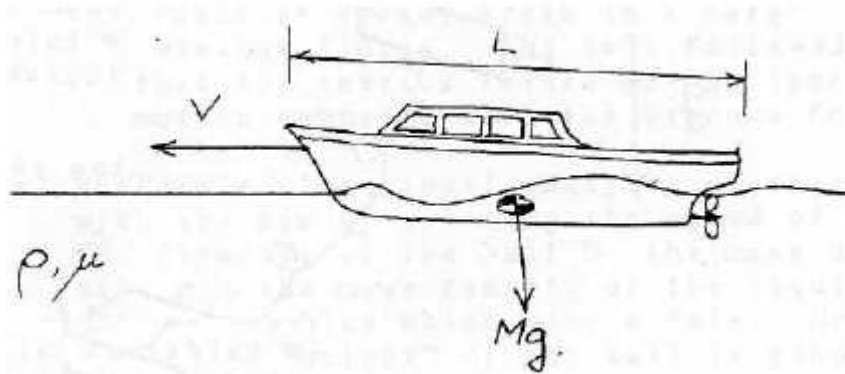
where v_z is the velocity at any radial location (r) and time (t).

Do the following

1. Use dimensional analysis to determine a dimensionless time (τ) and velocity (V) scale.
2. Use these new time and velocity scales to rewrite this equation in dimensionless form using the liquid density (ρ), viscosity (μ), and the pipe radius (R) as reference parameters.

Question 4:

P7.5 from "Advanced Fluid Mechanics Problem" Shapiro and Sonin.



A propeller-driven boat of length (L_1) and mass (M_1) is to move over calm water (density ρ , viscosity μ) at a speed V_1 . To determine what propeller speed ω_1 (Hz) will be required to do this, we test a 1/12 scale model which is a faithful geometric replica of the full-scale boat, including the propeller size and shape and the position of the boat's center of gravity. The model is to be tested on calm water. If we can argue that the water's viscosity should not significantly affect the required propeller speed,

1. What should be the mass M_2 of the model boat?
2. What should be the velocity V_2 of the model boat?
3. How is the full-scale propeller speed related to the propeller speed ω_2 required to keep the model going at the speed in (b)?
4. If the model requires a power P_2 , what power P_1 is required by the full-scale boat? (Consider only the power at the propeller, disregarding engine or drivetrain inefficiencies)