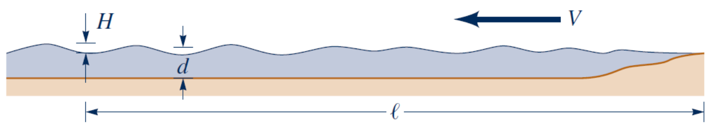
Homework set 10

Due: 2:10 PM – November 9, 2018

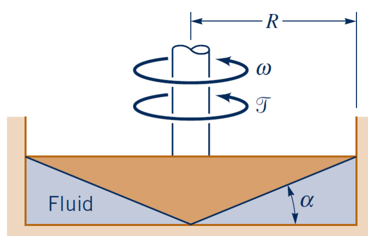
Problem 1

It is desired to determine the wave height when wind blows across a lake. The wave height, H, is assumed to be a function of the wind speed, V, the water density, ρ, the air density, ρ_a, the water depth, d, the distance from the shore, l, and the acceleration of gravity, g, as shown in the figure below. Use d, V, and ρ as repeating variables to determine a suitable set of pi terms that could be used to describe this problem.



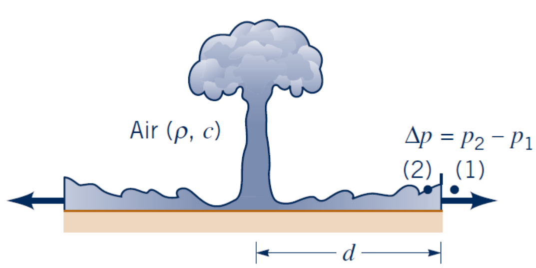
Problem 2

A cone and plate viscometer consists of a cone with a very small angle α that rotates above a flat surface as shown in the figure below. The torque, $\mathcal{T}$, required to rotate the cone at an angular velocity ω is a function of the radius, R, the cone angle, α, and the fluid viscosity, μ, in addition to ω. With the aid of dimensional analysis, determine how the torque will change if both the viscosity and angular velocity are doubled.



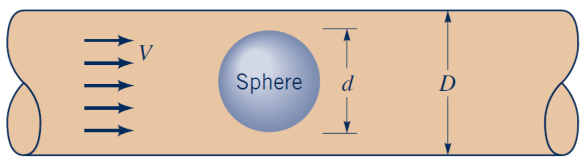
Problem 3

The pressure rise, Δp, across a blast wave, as shown in the figure below, is assumed to be a function of the amount of energy released in the explosion, E, the air density, ρ, the speed of sound, c, and the distance from the blast, d. (a) Put this relationship in dimensionless form. (b) Consider two blasts: the prototype blast with energy release E and a model blast with 1/1000th the energy release ($E_m = 0.001E$). At what distance from the model blast will the pressure rise be the same as that at a distance of 1 mile from the prototype blast?



Problem 4

The drag, $\mathcal{D}$, on a sphere located in a pipe through which a fluid is flowing is to be determined experimentally. Assume that the drag is a function of the sphere diameter, d, the pipe diameter, D, the fluid velocity, V, and the fluid density, ρ. (a) What dimensionless parameters would you use for this problem? (b) Some experiments using water indicate that for $d = 0.2$ in., $D = 0.5$ in., and $V = 2$ ft/s, the drag is 1.5×10^{-3} lb. If possible, estimate the drag on a sphere located in a 2-ft-diameter pipe through which water is flowing with a velocity of 6 ft/s. The sphere diameter is such that geometric similarity is maintained. If it is not possible, explain why not.

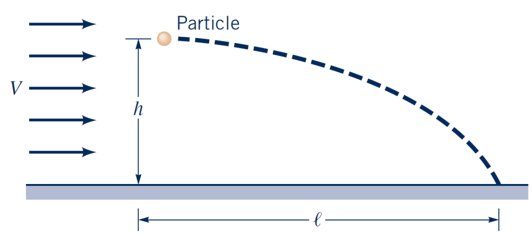


Problem 5

When small particles of diameter d are transported by a moving fluid having a velocity V, they settle to the ground at some distance l after starting from a height h as shown in the figure. The variation in l with various factors is to be studied with a model having a length scale of 1/10. Assume that

$$l = f(h, d, V, \gamma, \mu)$$

where γ is the particle specific weight and μ is the fluid viscosity. The same fluid is to be used in both the model and the prototype, but γ (model) $= 9 \times \gamma$ (prototype). (a) If $V = 50$ mph, at what velocity should the model tests be run? (b) During a certain model test it was found that l(model)$= 0.8$ ft. What would be the predicted l for this test?



TEXTBOOK

Munson, B.R., Okiishi, T.H., Huebsch, W.W., and Rothmayer, A.P., "Fundamentals of Fluid Mechanics", 7th Edition, 2013, John Wiley & Sons.