(1) (20)

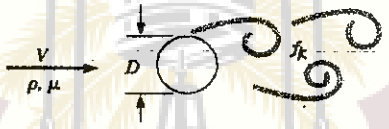
(a) (5) What is a Newtonian fluid?

(b) (5) How does the dynamic viscosity of gases vary with temperature?

(c) (10) What is cavitation? What causes it?

(2) (20) The volume and the average density of an irregularly shaped body are to be determined by using a spring scale. The body weighs 7200 N in air and 4790 N in water. Determine the volume and the density of the body. Assume the body is not porous and completely submerged in water. Where $\rho_w = 1000\ kg/m^3$. $g = 9.81\ m/s^2$.

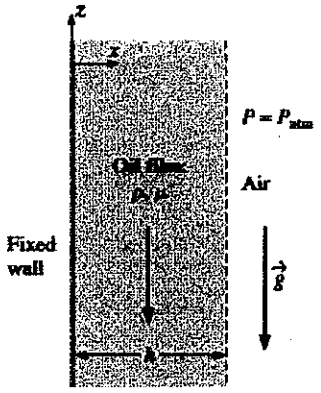
(3) (20) A periodic *Kármán vortex street* is formed when a uniform stream flows over a circular cylinder. Use the method of repeating variables to generate a dimensionless relationship for Kármán vortex shedding frequency f_k as a function of free-stream speed V, fluid density ρ, fluid viscosity μ, and cylinder diameter D. Show all your work.



(4) (20) Glycerin at 40°C with $\rho = 1252\ kg/m^3$ and $\mu = 0.27\ kg/m \cdot s$ is flowing through a 5-cm-diameter horizontal smooth and straight pipe with an average velocity of 3.5 m/s. The flow is fully developed and the pipe length is 10 m. The entrance effect is negligible. Determine the pressure drop of the pipe and the required pumping power.

(5) (20)

Consider steady, incompressible, parallel, laminar flow of a film of oil falling slowly down an infinite vertical wall. The oil film thickness is h, and gravity acts in the negative z-direction. There is no applied pressure gradient driving the flow—the oil falls by gravity alone. Write down Navier-Stokes equations, boundary conditions and assumptions. Use them to calculate the velocity and pressure fields in the oil film. You may neglect changes in the hydrostatic pressure of the surrounding air.



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