

MIT Department of Mechanical Engineering
2.25 Advanced Fluid Mechanics

Problem 7.14

This problem is from “Advanced Fluid Mechanics Problems” by A.H. Shapiro and A.A. Sonin

A fluid of density ρ and viscosity μ flows through a long pipe of diameter D at the volume flow rate Q .

- (a) Demonstrate that if the flow is laminar (*i.e.*, totally steady) and fully developed (the velocity profile and the pressure gradient no longer change with downstream distance x), the pressure gradient in the direction of flow must have the form

$$\frac{dp}{dx} = -K \frac{Q\mu}{D^4}$$

where K is constant.

- (b) Demonstrate that if the flow is turbulent (*i.e.*, unsteady) but steady and fully developed in the mean, the mean pressure gradient in the direction of flow must have the form

$$\frac{dp}{dx} = \left(\frac{\rho Q^2}{D^5} \right) \cdot \phi \left(\frac{\rho Q}{\mu D} \right)$$

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