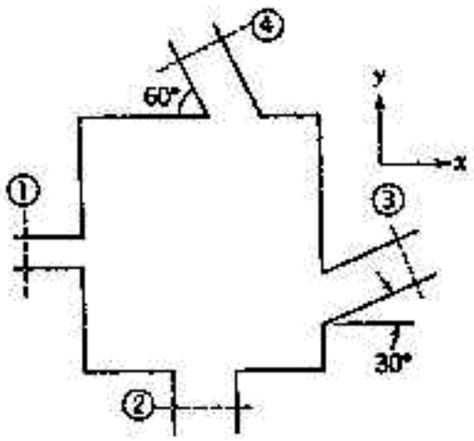
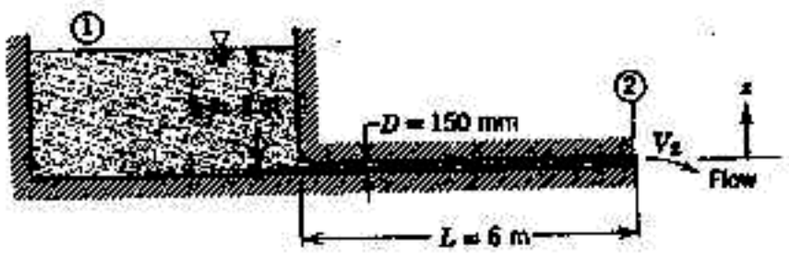
1. Consider steady flow of water through the device shown in the diagram. The areas are: A_1=0.02 m^2, A_2=0.05 m^2, and A_3= A_4=0.04 m^2. The mass flow rate out through section (3) is given as 56.7 kg/s. The volume flow rate in through section (4) is given as 0.03 m^3/s, and $\hat{V}_1$=3$\hat{i}$ m/s. If properties are assumed uniform across all inlet and outlet flow sections, determine the flow velocity at section (2). (Take ρ_{H_2O} = 1000 kg/m^3 in your calculation).
(30%)



2. A long pipe is connected to a large reservoir that initially is filled with water to a depth of 3m. The pipe is 150 mm in diameter and 6m long. As a first approximation, friction may be neglected. Determine the flow velocity leaving the pipe as a function of time after a cap is removed from its free end. The reservoir is large enough so that the change in its level may be neglected.
[hint: $\int \frac{dx}{1-x^2} = \tanh^{-1}(x)$] *(35%)*



3. (a) 20% (b) 15%

Crude oil flows through a level section of the Alaskan pipeline at a rate of 250 thousand cubic meters per day. The pipe inside diameter is 1200 mm; its roughness is equivalent to that of galvanized iron. The maximum allowable pressure is 8.3 Mpa; the minimum pressure required to keep dissolved gases in solution in the crude oil is 340 Kpa. The crude oil has SG=0.93; its viscosity at the pumping temperature of 60℃ is μ=0.017 N · S/m^2. For this conditions, determine (a) the maximum possible spacing between pumping stations. ***(20%)*** If the pump efficiency is 85 percent, determine (b) the power that must be supplied at each pumping station. ***(15%)***

(hint: the first law of thermodynamics to cv is

$$\dot{Q} - \dot{W}_s = \frac{\partial}{\partial t}\int_{cv} \rho e dv + \int_{cs}\left(u + \frac{v^2}{2} + gz + \frac{p}{\rho}\right)\rho \hat{v} \cdot d\hat{A}$$

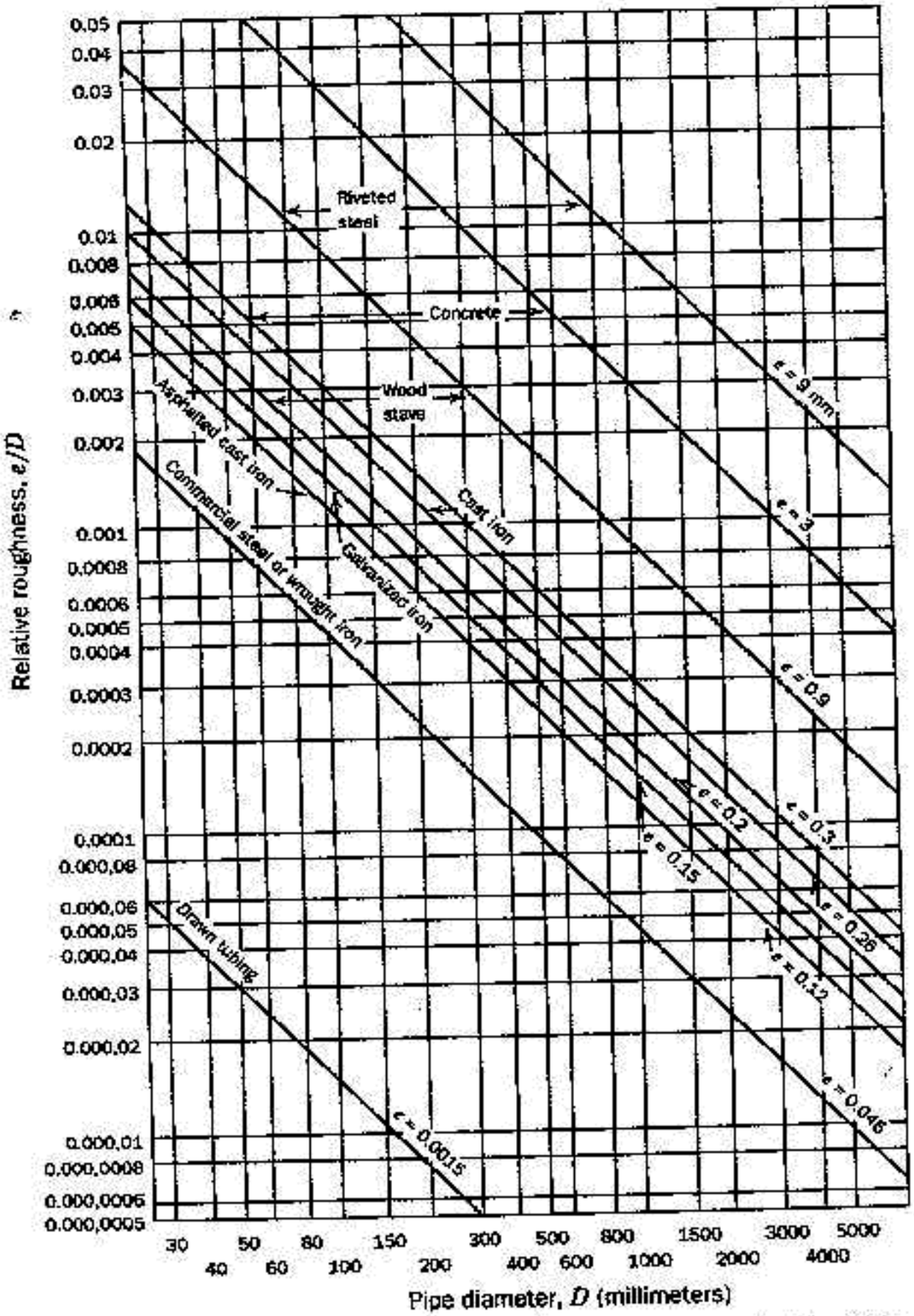


Fig. 1. Relative roughness for pipes of common engineering materials. (Data from [6], used by permission.)

國 立 清 華 大 學 命 題 紙

八十八學年度 工科系 系（所） 乙 組碩士班研究生招生考試

科目 流体力學 科號 3303 共 4 頁第 4 頁 *請在試卷【答案卷】內作答

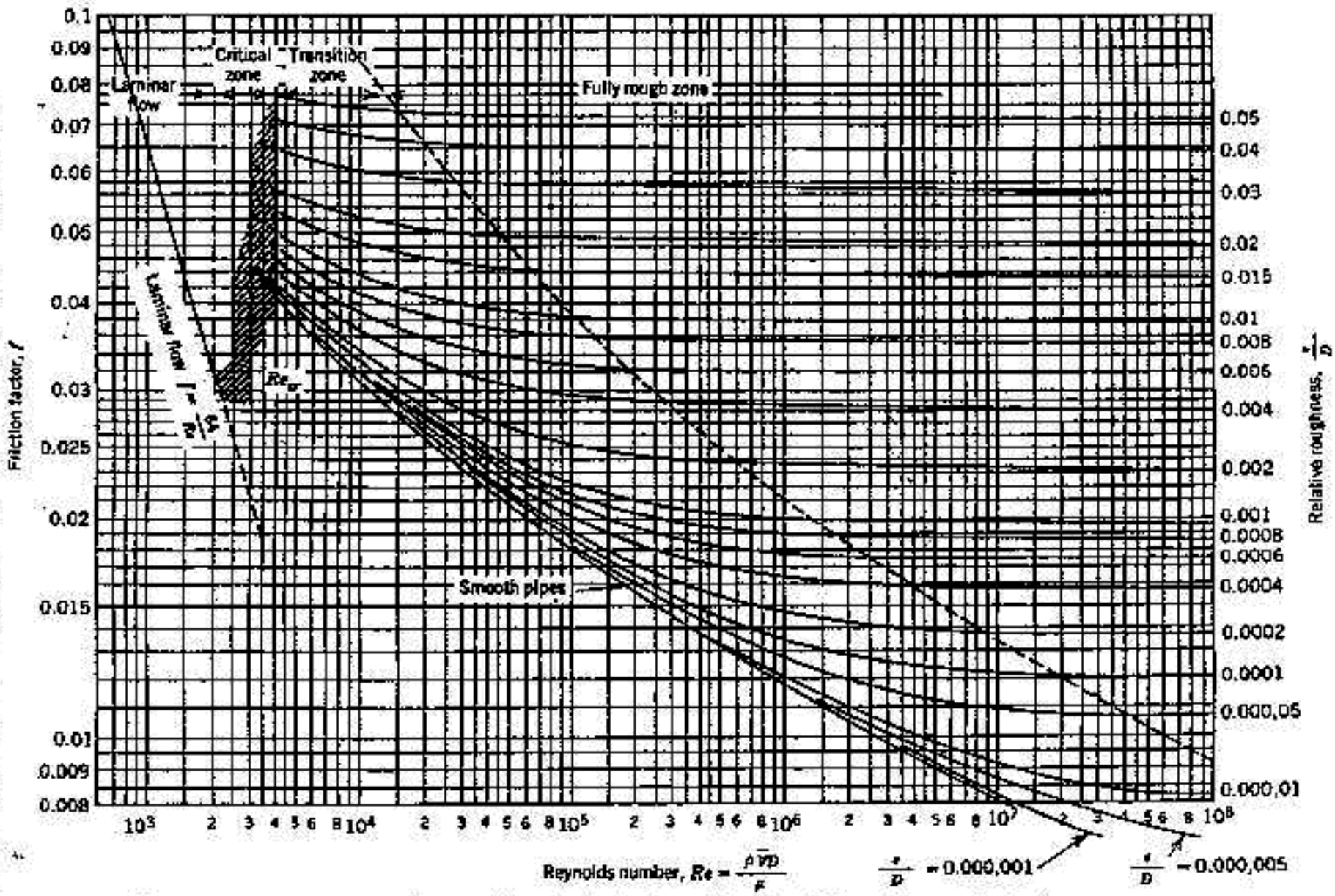


Fig. 2. Friction factor for fully developed flow in circular pipes. (Data from [6], used by permission.)