Civil PE Exam Review Course Manual

Instructor Reference

Second Edition

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Lesson 2: Fluid Mechanics

Suggestions for Instructor Review Prior to Class

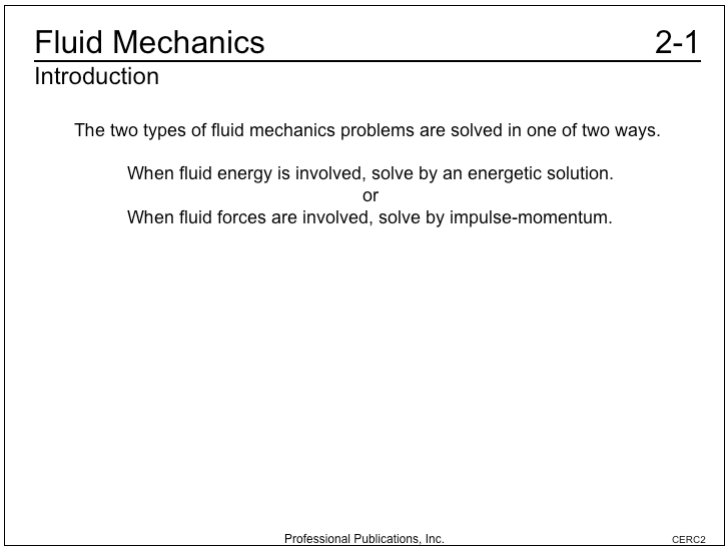
CERM Chs. 6–18

General Advice

You will usually need to combine the Bernoulli equation with network analysis principles to solve the more advanced problems. However, using just the Bernoulli equation will often suffice. This topic is desirable on the exam because most fluid mechanics problems can be solved well within the allotted time.

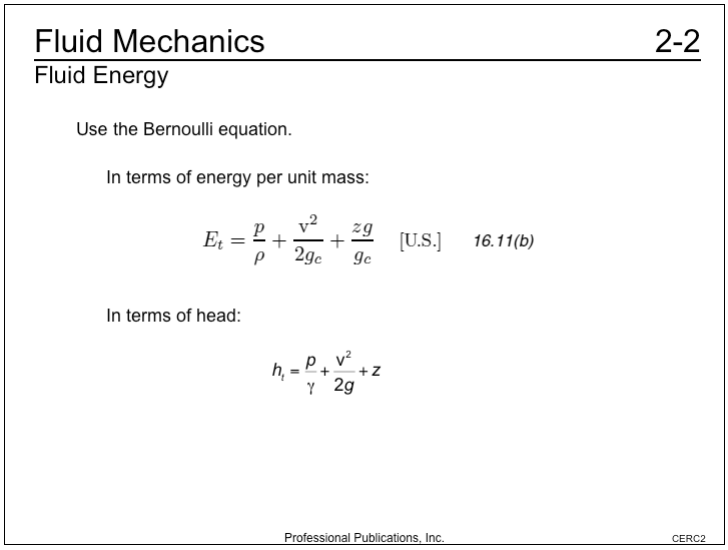
2-1 Introduction

The two types of fluid mechanics problems are solved in one of two ways: either by an energetic solution (when fluid energy is involved) or by impulse-momentum (when fluid forces are involved). The vast majority of exam problems require the energetic solution. Such problems will be covered extensively in this lecture.



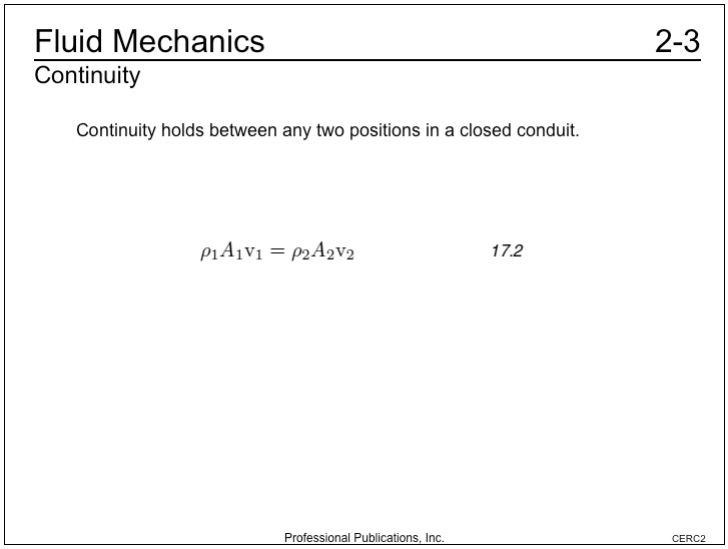
2-2 Fluid Energy

The Bernoulli equation (CERM Eq. 16.11b) governs fluid flow parameters in the energetic approach. The equation is made up of three terms, one each for pressure head, velocity head, and potential head. Hydraulic head is measured as a vertical distance from a horizontal datum, usually in units of feet or meters. This equation is a good opportunity to discuss units with the class. Note that g_c is not part of the equation.



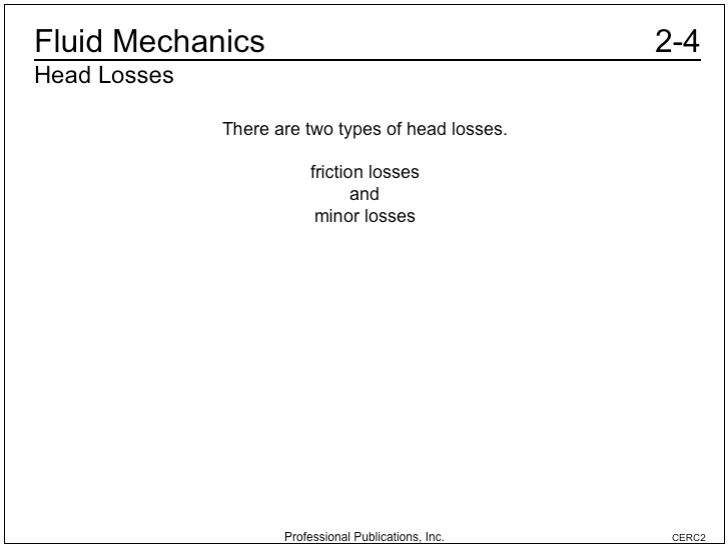
2-3 Continuity

Continuity (CERM Eq. 17.2) applies when the flow rate is constant between two points in the flow continuum.



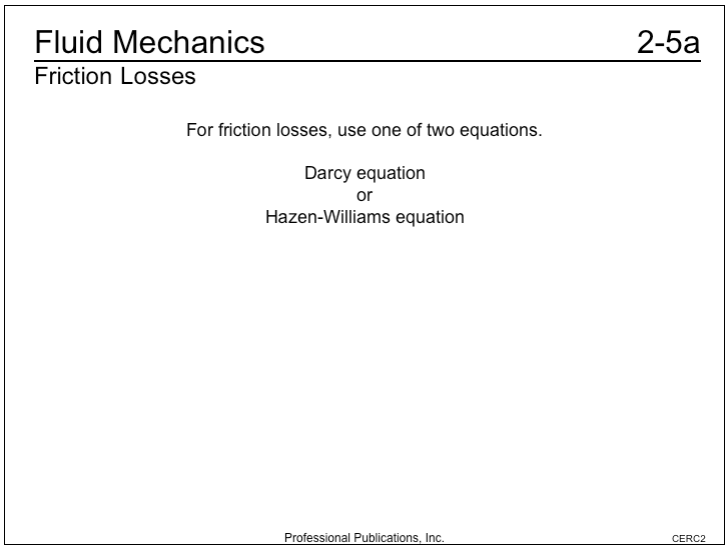
2-4 Head Losses

Head losses must be accounted for. There are two types of head loss: those due to friction and those due to anything other than friction (termed "minor" losses).

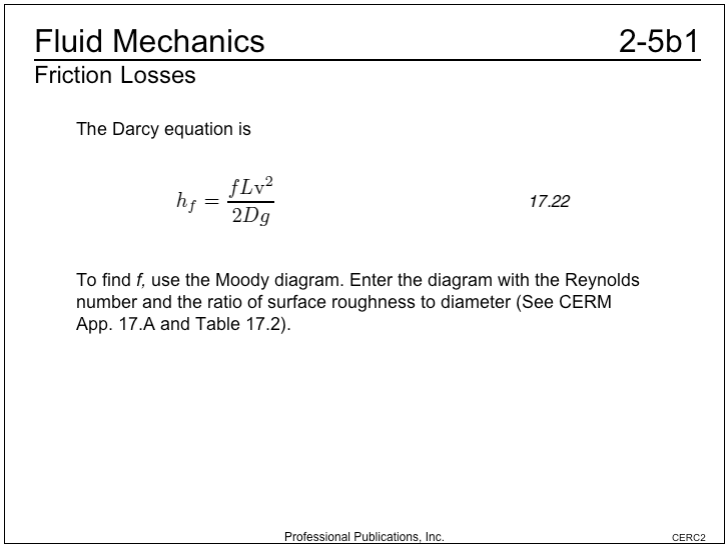


2-5 Friction Losses

The Darcy equation (CERM Eq. 17.22) is the common form for friction losses, but the Hazen-Williams equation (CERM Eq. 17.30) is also used occasionally on the exam.



The Darcy equation is used in conjunction with the Moody diagram (CERM Fig. 17.4) and requires the Reynolds number and the ratio of surface roughness to diameter to find *f* (CERM Table 17.2, App. 17.A).



Introduction

The two types of fluid mechanics problems are solved in one of two ways.

When fluid energy is involved, solve by an energetic solution.
or
When fluid forces are involved, solve by impulse-momentum.

Fluid Energy

Use the Bernoulli equation.

In terms of energy per unit mass:

$$E_t = \frac{p}{\rho} + \frac{v^2}{2g_c} + \frac{zg}{g_c} \quad \text{[U.S.]} \qquad 16.11(b)$$

In terms of head:

$$h_t = \frac{p}{\gamma} + \frac{v^2}{2g} + z$$

Continuity

Continuity holds between any two positions in a closed conduit.

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2 \qquad 17.2$$

Head Losses

There are two types of head losses.

friction losses
and
minor losses

Friction Losses

For friction losses, use one of two equations.

Darcy equation
or
Hazen-Williams equation

Friction Losses

The Darcy equation is

$$h_f = \frac{fLv^2}{2Dg} \qquad 17.22$$

To find *f,* use the Moody diagram. Enter the diagram with the Reynolds number and the ratio of surface roughness to diameter (See CERM App. 17.A and Table 17.2).